The emerging contribution of online resources and tools to classroom learning and teaching

A Report submitted to SchoolNet / Rescol

by TeleLearning Network Inc.

EXECUTIVE SUMMARY

Documentary Review (Full text)

December '98

The present document is an overview of a Documentary Review on the effective uses of online electronic resources and tools in the classroom. The mandate of the Review Team was to gather the pertinent information (written or otherwise) which has blossomed on networked learning (Internet and intranet) during the 1996-1998 period, thus updating the 1996 study, *The Contribution of New Technologies to Learning and Teaching in Elementary and Secondary Schools.* This review identifies models of use, trends, and research gaps on the contribution of effective uses of online resources and tools in the classroom of the elementary and secondary schools and post secondary institutions.

This review comes at a particularly convenient time since the United States (which constitutes a formidable professional and technical source of online information) has just placed " education " at the top of their investment agenda, a decision clearly supported, in a historical move, by the two principal political parties. Moreover, OECD just released a report on *The Global Research Village.*

For the purpose of this review, online resources and tools were defined as the information technology applied to teaching and learning for l) the delivery of educational material, 2) the guidance and facilitation of the learning experience of the student, and 3) the support of collaborative learning and communities of learners.

An extensive bibliographic search was conducted for articles, reports, papers, and books which had to meet rigorous selection criteria as a scholarly publication or as a controlled study. Furthermore, not only were we looking for a diversity of results pertaining to the use of online resources and tools in the classroom, but we paid a great amount of attention to the conditions or circumstances surrounding their effective use in order to bring useful information to teachers, educational administrators, and policy makers.

Our overall analysis is based on what are considered the four key elements that constitute the teaching/learning exercise: the teacher, the content, the learner(s), and the context. Each of these elements can be seen as a continuum having the characteristics illustrated in the following figure:

	TCLC -		TCLC+
Teacher	transmitter	_______	facilitator
Content	pre-organized	______	constructed
Learner[s]	low access	_____	high access
Content	limited support	_____	extensive support

The endpoints of each continuum define two contrasting models of technology use. For example, most current classrooms would lie toward the left ends of each continuum (**TCLC -**): 1) the teacher is a transmitter of knowledge rather than a facilitator of learning, 2) the content is pre-organized by the teacher or 'canned' on a CD-ROM rather than constructed by the learner; 3) the learners have low rather than high access to online resources and tools; and 4) the context offers the teacher and his or her classroom a limited rather than a high level of support for new initiatives and resources.

In contrast, the overwhelming thrust of research initiatives that examine the effects of online technologies are directed towards the opposite ends of each continuum: teacher/facilitator, content/constructed, learners/high access, context/extensive support (**TCLC+**). Again, the teacher primarily facilitates student learning, the curriculum content is constructed by the learners, the learners have free access to online resources, and the context supports the use and expansion of the resources.

There is evidence that the teacher plays a crucial role in the quality of the technology impact on the learning process, and there is also evidence that materials on the web (or on a CD-ROM) that offer stimulating and well-adapted content are a rare commodity.

Performance that leads to the most promising outcomes in teaching and learning is obtained by teachers whose pedagogies are more advanced and already oriented to search and make effective use of online resources and tools. Those teachers can also count on a champion in the school context which mobilizes resources, thus providing enough external support.

Effective uses of online resources and tools are now part of the renewal process of classroom teaching and learning. The following emerging trends capture the evidence that was gathered with respect to the effective uses of online resources and tools in the elementary and secondary classrooms on the one hand, and in the post-secondary classroom on the other hand.

THE EMERGING TRENDS IN THE RENEWAL PROCESS

The use of technology in the classroom has already been demonstrated to have a significant impact on teaching and learning. How the new technology is adopted is related to l) the users' interest in doing what they do well and in a better way, and 2) the users' interest in doing things of a different nature than the ones they are used to do. It is important to emphasize that both uses of technology are relevant to classroom learning.

For instance, in the first case, educators use technology to make their current teaching or classroom management easier, quicker, and more efficient. A significant characteristic of this use is the integration of technology into the curriculum. An example is the mathematics courseware called The Learning Equation Mathematics, the use of which led to superior performance by grade 9 students in mathematical knowledge, skills, number, pattern and shape compared to that of students using traditional textbooks and classroom techniques (Psychometrics Canada Ltd., 1998). Another example can be found in Wenglinsky (1998), whose analysis of a national database of student test scores, classroom computer use, and other information showed that grade 8 students whose teachers used computers mostly for "simulations and applications" - generally associated with higher-order thinking - performed better on National Assessment of Educational Progress evaluations than students whose teachers did not. The findings of both of these examples are significant because they come from large-scale assessment of outcomes and practices involving information technologies that are taking place in regular classrooms. In the second case, educators look at the new technological tools as an opportunity for the renewal of their practice, and to engage in a variety of activities (for instance, guided discovery and collaborative knowledge-building) for a broader vision of education that includes changes in learning needs and opportunities (McGilly, 1994; ASCD, 1998). With respect to the elements of the teaching/learning exercise (see Figure), in both cases, a transfer of responsibility occurs: in the first case, on the content element, and in the second case, on the learner.

The thrust of research on the use of online technologies is to support the development of teaching practices and curricula which give numerous opportunities to the learners to use the resources and tools in autonomous, creative, and collaborative ways. This work is more recent, thus at an earlier stage of development. Initiatives include the work of Bereiter and Scardamalia (1993) and Harasim, Hiltz, Teles, and Turoff (1995). The trends emerging from this work with respect to the K/12-13 sector and relevant other materials are the following:

- Trend 1: Higher levels of control by learners are called for as classrooms are getting more online.
- Trend 2: Learning situations become more realistic and authentic as classrooms are getting online.
- Trend 3: Online resources boost student interest and motivation in the classroom through a greater diversity of learning goals, projects, and outcomes.
- Trend 4: The successful online classroom combines information technology with appropriate pedagogy.
- Trend 5: The classroom is extended to online learning communities with the potential to support or even challenge the locally-established curriculum.
- Trend 6: The education of educators is broadened to include just-in-time and/or collaborative learning.
- Trend 7: Educators use online technology as a driving element of an educational reform.

With respect to the post-secondary classroom, the scholarly works and other relevant materials that were surveyed, made it possible to identify the following trends:

- Trend 1: The emergence of a new mixed mode of learning: face-to-face and online learning activities.
- Trend 2: Information access is more direct, interactive, and flexible.
- Trend 3: Social interaction recovers its importance in the learning process.
- Trend 4: The learning community, supported by networked technologies, is a new collaborative learning arrangement being tested in a great number of ways.
- Trend 5: Computer resources are used to enlarge the notion of performance as regards teaching and learning on university campuses.
- Trend 6: The university as an institution is invited to adapt its activity to new higher education needs.
- Trend 7: The computer linked to other computers constitutes an important element in the modification of academic administrative procedures at both the micro and the macro levels.

GAPS IN CURRENT KNOWLEDGE ABOUT ONLINE USE OF TECHNOLOGY IN THE CLASSROOM

The findings of this review also reveal gaps in our knowledge at both the K/12-13 and the post secondary levels. These gaps are the following:

I. Connectivity and access

Substantial access to online technologies, in terms of both resources and learner competence in making use of them, remains the exception in our classrooms. Given limited connectivity and access, research results reflecting practical uses of online resources and tools in the elementary and secondary school classrooms are scarce. More information is needed on what up-to-date resources are available (Schofield, Davidson, Stocks, and Futoran, 1998, p.371), the technology planning process of schools, boards, and faculties of education (ASCD, 1998; NCATE, 1997), and the ability of students to make effective use of online resources (Schacter, Gregory, Chung, and Dorr, 1998).

2. Professional development interface with online resources and tools

Effective use of online resources for learning means pairing the resources with an instructional approach that is very different from the traditional one. More information is needed on the nature and extent of teacher's experience with information technologies (Rosen and Weil, 1995), how teachers view these resources (Kerr, 1996), how they understand their impact on society as a whole (NCATE, 1997), and how they alter their instructional practices in order to use them effectively (Haymore Sandholtz, Ringstaff, and Dwyer, 1997; Maring, Wiseman & Myers, 1997). More information is needed on online professional development activities (nature, process, and results; Moonen, B. & Voogt, J.; Breuleux, Laferrière, and Bracewell, 1998).

3. Better balance between stable and dynamic content

The content of what will be taught using online resources is becoming more diverse and shifting towards more construction and input by the learner. More information is required on whether this more dynamic content conflicts with traditional curriculum content and goals (Saye, 1997), and, where it does, on how to reconcile these conflicts (Hewitt and Scardamalia, 1998).

4. Performance indicators for evaluating the use and impact of online technologies

As the presence and use of information technologies become increasingly widespread, schools and universities will need to develop performance indicators to monitor the use and outcomes of the technologies, and to demonstrate accountability to funding sources and the public. These indicators are needed specifically to monitor the types of resources available, and access to them, professional development efforts, changes in teaching and learning practices, and changes in what is learned by students (Wenglinsky, 1998; Windschitl, 1998; Bordia, 1997; Harrington and Quinn-Leering, 1996).

RECOMMENDATIONS

In view of the above findings, we recommend that policy and research initiatives should be guided by the following approaches:

- **a reflective approach to teaching (teachers-as-researchers).** The use of online resources and tools by teachers should be informed by reflective practice that takes into account empirical evidence, rather than personal theories-in-use. The teaching profession must aim in this direction. The significance of this change is that it almost certainly entails a revised approach to teaching that puts less emphasis on teacher-centered activities. The learner is to be envisioned as capable of engaging in a variety of learning projects. New pedagogical strategies that support him or her in the acquisition of intellectual autonomy will need to be developed.

- **the collaborative learning/research approach.** Online technology is evolving rapidly. The traditional knowledge transfer model of research followed by dissemination, may not be a-flexible-or-fast-enough a process to respond to the emerging needs, as is well-exemplified in the following paragraph.
- **a design experiment approach.** Issues of "design" are prevalent today and could be supported by more direct "design experiment" frameworks for vigorous discussions of the contexts, contents, and processes that ensure the attainment of proper conditions for online learning. For such conditions to be established, it is recommended that the following research procedures be adopted:

    - the visioning of a wired classroom, institution, or educational system emphasizing content and pedagogy;
    - the planning of an incremental process of change;
    - the implementation of the above approaches with a high level of coordination among stakeholders responsible for education;
    - the initiation of a renewal process with respect to all of the four constituents that must be combined to form models of use with built-in professional development activities;
    - the endowment of research settings (meaning primary and secondary schools as well as colleges and universities) willing and capable of initiating and conducting:
        - innovative reflective action with respect to the learners' access to online resources and tools, teaching practices, and contextual factors;
        - relevant surveys, case studies, and longitudinal studies;
        - assessment and performance reviews.

Specific studies would also be instrumental to reduce research gaps, and enhance educational research in Canada. Here are a few examples of such research topics:

- the level of Canadian teachers' experience with computers, building on the findings of Rosen and Weil in the United States (1995);
- the level of student access to computers linked to a network (intranet and Internet) for subject specific tasks or project-based learning that integrate

a number of subject matters, using schools' technology plans (1995 and on).

- collaborating partners' theories of action, one that would build on Hatch's results (1998);
- educators' perceptions of the properties of online technology - " a tool for improving the ways we do things now, a set of devices and procedures that allow us to extend the efficiency and the effectiveness of schooling without altering underlying assumptions about the roles and relationships of the students, teachers, parents, and administrators involved (...) or a very different kind of tool - one oriented toward the development of individual capacities in a social context and toward restructuring the work of schools", as Kerr puts it in concluding Chapter I of *Technology and the future of Schooling* (1996);
- the mind-sets that are behind the conflicting practices of educators (beliefs about content, method, organization, and evaluation of curriculum), building on White and Purdom's results (1996);
- beliefs about what constitutes success, for instance, building on Knapp's findings in math and science education (1997);
- advanced topic mastered with the use of online resources and tools, building on Dede's findings as editor of the 1998 *ASCD Yearbook on Learning with technology.*
- outcomes on standardized tests, building on Wenglinsky's findings (1998);
- many other research projects which would be of a sufficiently high (complex) and formal level to support conclusions being made by technology adopters when learning outcomes are considered, as pointed out by Jones and Paolucci (1998) in their review of over 800 research articles associated with technology in education dating back to 1992. As mentioned by Wenglinsky (1998), the Mandinach and Cline's study (in press) will stress the need for the use of technology over well-defined periods of time in order to conduct controlled experiments that will contribute to build the evidence on its contribution to learning and teaching.

The classroom is a place where order prevails. The infusion of information and communication technologies (ICTs) creates a zone of uncertainty for both teachers and learners, engaging them in a process of risk and exploration for some time to come. Research on one or the other of the four basic elements of each 'extreme' model of use (**TCLC -** : teacher/transmitter, content/pre-organized, learners/low access, context/limited support; **TCLC +** : teacher/facilitator, content/constructed, learners/high access, context/ extensive support) while neglecting the others, is bound to lead to partial and confusing results. The Review Team emphasizes that a focus on one element at the expense of the others tends to raise superficial questions and unproductive debates. The interdependence of the four fundamental elements that this review takes into account (and highly recommends for consideration in all further inquiry) should be progressively documented with respect to the impact of online technologies on teaching and learning in the classroom. More recent conceptual developments occurring in other fields such as the learning organization framework, and the new domain of knowledge management, seem to point in the same direction.

In conclusion, the Review Team expects that those countries that will develop rich conceptions of teaching, learning, content, and context as they provide knowledge building opportunities and shared social experiences to learners in the elementary, secondary, or post-secondary classroom will simultaneously enhance their research capacity. The significance of such a choice may be felt as one's reads the quite evocative recent OECD Report, entitled: *The Global Research Village: How Information and Communication Technologies Affect the Science System.*

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La contribution naissant des ressources et des outils en ligne
à l'apprentissage et à l'enseignement en classe

Projet de rapport soumis à Rescol / SchoolNet
par TeleLearning Network Inc.

RÉSUMÉ

Le présent document donne un aperçu de l'examen de documents portant sur l'utilisation efficace de ressources et d'outils électroniques en ligne dans la salle de classe. Le groupe chargé d'examiner ces documents avait pour mandat de réunir les données pertinentes (écrites ou autres) qui sont apparues au sujet de l'apprentissage réseauté (Internet et intranet) pendant la période allant de 1996 à 1998, afin de mettre à jour l'étude de 1996 intitulée *The Contribution of New Technologies to Learning and Teaching in Elementary and Secondary Schools.* Cet examen a permis de repérer des modèles d'utilisation, des tendances et des lacunes dans la recherche sur la contribution des utilisations efficaces de ressources et d'outils en ligne en salle de classe, dans les écoles primaires et secondaires et dans les établissements d'enseignement postsecondaire.

Cet examen intervient à un moment tout à fait opportun, car les États-Unis (qui représentent une source professionnelle et technique fantastique de données en ligne) viennent de placer l'éducation en tête des priorités de leur programme d'investissement, décision que les deux principaux partis politiques soutiennent manifestement, ce qui est historique en soi. En outre, l'OCDE vient de publier un rapport sur *The Global Research Village*.

Aux fins de cet examen, les ressources et les outils en ligne sont définis comme étant l'infotechnologie appliquée à l'enseignement et à l'apprentissage pour (l) transmettre du matériel éducatif, (2) guider l'étudiant dans son apprentissage et de faciliter celui-ci, et (3) soutenir l'apprentissage coopératif et aider les groupes d'apprenants.

Une recherche bibliographique approfondie a été menée afin de trouver des articles, des rapports, des exposés et des ouvrages qui devaient satisfaire à des critères de sélection rigoureux en tant que publication érudite ou qu'étude menée dans des conditions contrôlées.

De plus, nous avons non seulement recherché divers résultats concernant l'utilisation de ressources et d'outils en ligne dans les salles de classe, mais nous avons également prêté une grande attention aux conditions ou aux circonstances qui entouraient leur bonne utilisation afin de fournir des renseignements utiles aux enseignants, aux administrateurs scolaires et aux décideurs.

Notre analyse générale repose sur ce que l'on considère comme les quatre éléments clés de l'enseignement et de l'apprentissage : l'enseignant, le contenu, le ou les apprenants et le contexte. Chacun de ces éléments peut être considéré comme un continuum qui présente les caractéristiques suivantes :

	ECAC-		ECAC+
ENSEIGNANT	**émetteur†**	__________	**facilitateur**
CONTENU	**pré-organisé**	__________	**structuré**
APPRENANTS	**accès limité**	__________	**grand accès**
CONTEXTE	**soutien limité**	______	**soutien généralisé**

Les extrémités de chaque continuum définissent deux modèles d'utilisation de la technologie opposés. Par exemple, la plupart des classes actuelles tendraient vers l'extrémité gauche de chaque continuum (**ECAC-**): (1) l'enseignant transmet des connaissances plus qu'il ne facilite l'apprentissage; (2) le contenu est organisé à l'avance par l'enseignant ou « fixé » sur un CD-ROM plutôt que construit par l'apprenant; (3) les apprenants ont assez peu accès à des ressources et à des outils en ligne; et (4) le contexte se prête assez peu, pour l'enseignant ou l'enseignante et sa classe, à de nouvelles initiatives et à l'emploi de nouvelles ressources.

À l'opposé, dans l'immense majorité des cas, les travaux de recherche qui portent sur les effets des technologies en ligne tendent vers l'extrémité inverse de chaque continuum : enseignant/facilitateur, contenu/structuré, apprenants/grand accès, contexte/soutien généralisé (**ECAC+**). Là encore, l'enseignant facilite avant tout l'apprentissage de l'étudiant, le contenu du programme d'études est construit par les apprenants, ces derniers ont librement accès à des ressources en ligne, et le contexte est favorable à l'utilisation et à l'expansion des ressources.

Il est évident que l'enseignant joue un rôle essentiel dans la qualité de l'incidence de la technologie sur le processus d'apprentissage, et il est évident aussi que les documents dont le contenu est stimulant ou bien adapté sont une denrée rare sur Internet (ou sur CD-ROM).

Les résultats les plus prometteurs dans l'enseignement et l'apprentissage sont obtenus par des enseignants dont les pédagogies sont plus avancées et déjà orientées vers la recherche et l'utilisation efficace de ressources et d'outils en ligne. Ces enseignants peuvent également compter sur un champion dans le contexte scolaire qui mobilise des ressources et fournit donc un appui extérieur suffisant.

Les utilisations efficaces des ressources et des outils en ligne font maintenant partie du processus de renouvellement de l'enseignement et de l'apprentissage en classe. La nouvelle tendance suivante illustre les éléments probants réunis en ce qui concerne les utilisations efficaces des ressources et des outils en ligne dans les classes des écoles primaires et secondaires, d'une part, et dans les classes de l'enseignement postsecondaire, d'autre part.

LES NOUVELLES TENDANCES DU PROCESSUS DE RENOUVELLEMENT

Il a déjà été démontré que l'utilisation de la technologie en classe influe sensiblement sur l'enseignement et sur l'apprentissage. L'adoption même de la nouvelle technologie dépend (l) de l'envie des utilisateurs de faire ce qu'ils font bien et mieux, et (2) de leur envie de faire des choses différentes de celles qu'ils ont l'habitude de faire. Il est important de souligner que les deux utilisations de la technologie sont pertinentes en ce qui concerne l'apprentissage en classe.

Par exemple, dans le premier cas, les éducateurs utilisent la technologie pour faciliter l'enseignement ou la gestion courante de la classe, pour gagner du temps et pour être plus efficace. L'intégration de la technologie au programme d'études est une caractéristique importante de ce type d'utilisation. Le didacticiel de mathématiques *The Learning Equation Mathematics*, dont l'utilisation a permis d'obtenir avec des élèves de 9^e année des résultats, pour les connaissances des mathématiques, l'arithmétique, les nombres, les courbes et les figures, supérieurs à ceux obtenus avec des élèves avec qui on utilisait des manuels et des techniques pédagogiques classiques, en est une illustration (Psychometrics Canada Ltd., 1998). Wenglinsky (1998) en fournit une autre. En effet, il ressort de son analyse d'une base de données nationale des résultats de tests scolaires et de l'utilisation des ordinateurs en classe, entre autres, que les élèves de 8^e année dont les enseignants utilisaient des ordinateurs principalement pour des « simulations et des applications » généralement associées avec une réflexion plus poussée obtenaient de meilleurs résultats lors du National Assessment of Educational Progress que les autres élèves. Les conclusions des deux exemples sont importantes parce qu'elles découlent d'une évaluation à grande échelle de résultats et de méthodes faisant intervenir des technologies de l'information dans les classes ordinaires. Dans le deuxième cas, les éducateurs considèrent les nouveaux outils technologiques comme une occasion de renouveler leur méthode et d'entreprendre diverses activités (par exemple, l'apprentissage par la découverte guidée et le renforcement des connaissances en coopération), d'où une vision plus large de l'enseignement qui tient compte de l'évolution des besoins et des possibilités en matière d'apprentissage (McGilly, 1994; ASCD, 1998). En ce qui concerne les éléments de l'exercice d'enseignement et d'apprentissage (voir tableau), dans les deux cas, il se produit un transfert de responsabilité : dans le premier cas, à propos de l'élément de contenu, et dans le second, sur l'apprenant.

La recherche sur l'utilisation de technologies en ligne vise à appuyer l'élaboration de méthodes pédagogiques et de programmes d'études qui donnent aux apprenants de nombreuses possibilités d'utiliser des ressources et des outils de manière autonome et créative et en coopération. Elle est plus récente et donc à un stade de développement encore précoce. Parmi les travaux terminés, citons ceux de Bereiter et Scardamalia (1993) et de Harasim, Hiltz, Teles et Turoff (1995). Les tendances qui se dégagent de cette recherche en ce qui concerne le secteur allant de la maternelle à la 12^e et 13^e année et d'autres éléments pertinents sont les suivantes :

Tendance 1 : Un plus grand degré de contrôle par les apprenant est attendu des apprenants à mesure que les classes se branchent à Internet.

Tendance 2 : Les situations d'apprentissage deviennent plus réalistes et authentiques à mesure que les classes se branchent à Internet.

Tendance 3 : Les ressources en ligne augmentent l'intérêt et la motivation des élèves en classe en diversifiant les objectifs d'apprentissage, les projets et les résultats.

Tendance 4 : La classe branchée qui fonctionne bien combine la technologie de l'information avec une pédagogie appropriée.

Tendance 5 : La classe s'élargit à des groupes d'apprenants en ligne, ce qui offre un potentiel de soutien voire de défi au programme d'études local.

Tendance 6 : La formation des éducateurs s'élargit pour inclure un apprentissage à la carte et/ou en coopération.

Tendance 7 : Les éducateurs utilisent la technologie en ligne comme moteur d'une réforme de l'enseignement.

En ce qui concerne les classes de l'enseignement postsecondaire, il a été possible de cerner les tendances suivantes dans les travaux érudits et autres documents pertinents qui ont été examinés :

Tendance 1 : L'apparition d'un nouveau mode d'apprentissage panaché fait d'activités d'apprentissage en vis-à-vis et en ligne.

Tendance 2 : L'accès à l'information est plus direct, interactif et souple.

Tendance 3 : L'interaction sociale retrouve son importance dans le processus d'apprentissage.

Tendance 4 : La communauté apprenante, soutenue par des technologies mises en réseau, constitue un nouveau dispositif d'apprentissage en coopération qui est mis à l'épreuve de bien des façons.

Tendance 5 : Les ressources informatiques sont utilisées pour élargir la notion de résultats en ce qui a trait à l'enseignement et à l'apprentissage sur les campus universitaires.

Tendance 6 : L'université en tant qu'institution est invitée à adapter son activité aux nouveaux besoins de l'enseignement supérieur.

Tendance 7 : L'ordinateur relié à d'autres ordinateurs constitue un élément important dans la modification des procédures administratives universitaires, tant au niveau local que général.

LACUNES DES CONNAISSANCES COURANTES SUR L'UTILISATION EN LIGNE DE LA TECHNOLOGIE DANS LES SALLES DE CLASSE

Les conclusions du présent examen révèlent également des lacunes dans nos connaissances de ce qui se passe de la maternelle à la 12^e et 13^e année et dans l'enseignement postsecondaire. Ces lacunes sont les suivantes :

1. Connectivité et accès

Un accès important à des technologies en ligne, tant sur le plan des ressources que des compétences des apprenants à les utiliser, demeure l'exception dans nos salles de classe. Étant donné la connectivité et l'accès limités, les résultats de recherches rendant compte d'utilisations pratiques de ressources et d'outils en ligne dans les classes des écoles primaires et secondaires sont rares. Davantage de données sont nécessaires sur les ressources modernes qui sont disponibles (Schofield, Davidson, Stocks et Futoran, 1998, p. 371), sur le processus de planification technologique des écoles, des conseils et des facultés d'enseignement (ASCD, 1998; NCATE, 1997), et sur l'aptitude des élèves à bien utiliser des ressources en ligne (Schacter, Gregory, Chung et Dorr, 1998).

2. Corrélation entre perfectionnement professionnel et ressources et outils en ligne

Une utilisation efficace de ressources en ligne aux fins d'apprentissage signifie que l'on allie les ressources à une approche pédagogique très différente d'une approche traditionnelle. Plus de données sont nécessaires pour connaître la nature et l'ampleur de l'expérience de l'enseignant avec les technologies de l'information (Rosen et Weil, 1995), l'opinion que les enseignants ont de ces ressources (Kerr, 1996), la compréhension qu'ils ont de l'incidence des technologie sur la société dans son ensemble (NCATE, 1997), et la façon dont ils modifient leurs méthodes pédagogiques afin de les utiliser efficacement (Haymore Sandholtz, Ringstaff et Dwyer, 1997; Maring, Wiseman et Myers, 1997). Plus de données sont également nécessaires sur les activités de perfectionnement professionnel en ligne (nature, processus et résultats; Moonen, B. et Voogt, J.; Breuleux, Laferrière et Bracewell, 1998).

3. Meilleur équilibre entre un contenu stable et dynamique

Le contenu de l'enseignement qui utilise des ressources en ligne se diversifie et l'apprenant participe davantage à sa construction. Plus de données sont nécessaires pour savoir si ce contenu plus dynamique s'oppose au contenu et aux objectifs des programmes d'études traditionnels (Saye, 1997) et, dans l'affirmative, pour déterminer comment résoudre ce conflit (Hewitt et Scardamalia, 1998).

4. Indicateurs de performance pour évaluer l'utilisation et l'incidence des technologies en ligne

La présence et l'utilisation de technologies de l'information se généralisant de plus en plus, les écoles et les universités devront élaborer des indicateurs de performance afin de pouvoir évaluer l'utilisation des technologies et les résultats obtenus, et de rendre des comptes aux sources de financement et au public. Ces indicateurs sont nécessaires précisément pour faire un suivi des types de ressources disponibles, et de leur accessibilité, et pour évaluer les efforts de perfectionnement professionnel, l'évolution des méthodes d'enseignement et d'apprentissage, et l'évolution de la matière apprise par les étudiants (Wenglinsky, 1998; Windschitl, 1998; Bordia, 1997; Harrington et Quinn-Leering, 1996).

RECOMMANDATIONS

Étant donné les conclusions ci-dessous, nous recommandons de fonder les initiatives en matière de politique et de recherche sur les approches suivantes :

- **un enseignement réfléchi (l'enseignant-chercheur).** Les enseignants doivent faire une utilisation informée des ressources et des outils en ligne, c'est-à-dire s'appuyer sur une réflexion dans laquelle ils tiennent compte de données empiriques plutôt que de théories personnelles. Le corps enseignant va dans ce sens. Ce changement signifie presque certainement qu'il faut revoir la démarche pédagogique de manière à mettre moins l'accent sur des activités axées sur l'enseignant. Il faut considérer que l'apprenant est capable de participer à divers projets d'apprentissage. Il sera nécessaire de définir de nouvelles stratégies pédagogiques qui le soutiendront dans l'acquisition de l'autonomie intellectuelle.

- **un apprentissage et des recherches menés en coopération.** La technologie en ligne évolue rapidement. Le modèle de recherche traditionnel sur le transfert des connaissances suivi de la diffusion n'est sans doute pas assez souple ou rapide pour répondre aux nouveaux besoins, comme le montre le paragraphe suivant.

- **l'expérimentation des concepts.** Les problèmes de « concept » sont fréquents aujourd'hui et l'on pourrait les résoudre en utilisant des cadres d'« expérimentation » plus directs qui permettraient d'analyser en profondeur les contextes, les contenus et les processus qui assurent la mise en place des conditions voulues pour un apprentissage en ligne. Pour mettre en place ces conditions, il est recommandé d'adopter les méthodes de recherche suivantes :

    - visualiser une classe, un établissement ou un système éducatif branché qui met l'accent sur le contenu et la pédagogie;

    - planifier un processus de changement progressif;

    - mettre en œuvre les approches ci-dessus avec un grand degré de coordination entre les intervenants chargés de l'enseignement;

    - entamer un processus de renouvellement des quatre éléments constituants qui doivent être combinés pour former des modèles d'utilisation comprenant des activités de perfectionnement professionnel;

    - financer des cadres de recherche (autrement dit, des écoles primaires et secondaires ainsi que des collèges et des universités) capables et disposés à entreprendre et à mener :

        - une réflexion novatrice en ce qui concerne l'accès des apprenants à des ressources et à des outils en ligne, les méthodes d'enseignement et les facteurs contextuels;

        - les enquêtes, les études de cas et les études longitudinales pertinentes;

        - des évaluations et des examens des résultats.

Certaines études aideraient également à combler les lacunes en matière de recherche et à renforcer la recherche pédagogique au Canada. Voici quelques exemples de ces thèmes de recherche :

- Le niveau d'expérience en informatique des enseignants canadiens, en s'appuyant sur les conclusions de Rosen et Weil aux États-Unis (1995);
- Le degré d'accès des étudiants à des ordinateurs reliés à un réseau (intranet et Internet) pour des tâches particulières à une matière ou pour un apprentissage reposant sur des projets qui intègrent plusieurs matières, en utilisant des plans relatifs à la technologie à l'école (à partir de 1995).
- Les théories de partenaires dans l'action, en s'appuyant sur les résultats de Hatch (1998);
- Les perceptions que les éducateurs ont des propriétés de la technologie en ligne « en tant qu'outil permettant d'améliorer nos méthodes de travail, qu'ensemble de dispositifs et de procédures qui nous permettent de rendre la scolarité plus efficace sans modifier les hypothèses sous-jacentes en ce qui concerne les rôles et les relations des étudiants, des enseignants, des parents et des administrateurs concernés », ou que sorte d'outil très différent « orienté vers le développement des capacités individuelles dans un contexte social et vers une restructuration du travail des écoles », comme le dit Kerr en conclusion du chapitre l de *Technology and the future of Schooling* (1996);
- Les attitudes bien ancrées qui se cachent derrière les méthodes contradictoires des éducateurs (convictions quant au contenu, à la méthode, à l'organisation et à l'évaluation du programme d'études), en s'appuyant sur les résultats de White et Purdom (1996);
- Les convictions quant à ce qui constitue le succès, par exemple, en s'appuyant sur les conclusions de Knapp en ce qui concerne l'enseignement des mathématiques et des sciences (1997);
- Matière avancée maîtrisée grâce à l'utilisation de ressources et d'outils en ligne, en s'appuyant sur les conclusions de Dede, qui dirigeait l'étude de 1998 intitulée *ASCD Yearbook on Learning with technology.*
- Les résultats de tests standardisés, en s'appuyant sur les conclusions de Wenglinsky (1998);

- Beaucoup d'autres projets de recherche qui seraient d'un niveau (de complexité) assez élevé et formel pour soutenir les conclusions tirées par ceux qui adoptent la technologie en ce qui concerne les résultats de l'apprentissage, comme le soulignent Jones et Paolucci (1998) dans leur examen de plus de 800 articles de recherche liés à la technologie dans l'éducation, datant de 1992 à 1998. Comme le mentionne Wenglinsky (1998), l'étude de Mandinach et Cline (sous presse) montrera qu'il est nécessaire d'utiliser la technologie sur des périodes de temps bien définies afin de mener des expériences contrôlées qui aideront à réunir des preuves de sa contribution à l'apprentissage et à l'enseignement.

La salle de classe est un endroit où l'ordre prévaut. L'arrivée des technologies de l'information et des communications (TIC) crée une zone d'incertitude pour les enseignants et pour les apprenants, ce qui les entraîne dans un processus de risque et d'exploration pour quelque temps. En faisant une recherche sur l'un ou l'autre des quatre éléments fondamentaux de modèles d'utilisation « extrêmes » (**ECAC -** : enseignant/émetteur, contenu/fixe, apprenants/accès limité, contexte/soutien limité; **ECAC +** : enseignant/facilitateur, contenu/structuré, apprenants/grand accès, contexte/soutien généralisé) tout en négligeant les autres, on obtiendra forcément des résultats partiels et déroutants. Le groupe d'examen insiste sur le fait que mettre l'accent sur un élément au détriment des autres tend à soulever des questions superficielles et des débats stériles. L'interdépendance des quatre éléments fondamentaux dont cet examen tient compte (ce qui est fortement recommandé pour toute étude ultérieure) doit être progressivement documentée pour ce qui est de l'incidence des technologies en ligne sur l'enseignement et sur l'apprentissage en classe. Des développements conceptuels plus récents qui interviennent dans d'autres domaines tels que le cadre d'organisation de l'apprentissage et le nouveau domaine de la gestion des connaissances semblent aller dans le même sens.

En conclusion, le groupe d'examen s'attend à ce que les pays qui élaboreront des conceptions inventives de l'enseignement, de l'apprentissage, du contenu et du contexte pour offrir aux apprenants des écoles primaires, secondaires et postsecondaires des possibilités de renforcement des connaissances et d'expériences sociales communes, amélioreront en même temps leur capacité de recherche. On comprendra l'importance de ce choix en lisant le rapport très évocateur que vient de publier l'OCDE sous le titre *The Global Research Village: How Information and Communication Technologies Affect the Science System.*

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The emerging contribution of online resources and tools to classroom learning and teaching

(Texte français en traduction)

Executive Summary

Report submitted to

SchoolNet / Rescol

by TeleLearning Network Inc.

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Appendix A: Methodological notes

Introduction

The goal of this documentary review is twofold: 1) to update the first review, entitled *The Contribution of New Technologies to Learning and Teaching in Elementary and Secondary Schools,* prepared for SchoolNet and published on TACT Website in the summer of 1996; and 2) to identify the research gaps on the impact and effective uses of online tools and resources in the classroom.

The present Review, covering the 1996-1998 period, aims at informing educational leaders, including teachers working inside their own classroom, on the effective uses of online technology. Whereas the 1996 document dealt with the contribution of computer technology on learning and teaching as a whole for the K/12-13 sector only, this paper focuses on the uses of information and communication technologies (ICTs), both in the K/12-13 as well as in the post-secondary lab or classroom. The locus of use being the classroom, that is, the place where teachers and students meet face to face on a regular basis, this Review does not systematically cover studies in distance education/learning per se. However, such studies will sometimes be referred to and used to corroborate or emphasize specific results pertaining to the 'regular' classroom.

A comprehensive framework emphasizing extreme circumstances of use is brought forward, followed by propositions that organize results found in scholarly works and other highly relevant studies, pointing to emerging trends in the process. For practical reasons, trends pertaining to the K/12-13 sector are distinguished from those pertaining to the post-secondary sector. Both sectors differ, but they also manifest underlying general trends.

This presentation of the early results of the use of online resources and tools in the classroom is meant to provide a basis for future research orientations. Policy makers, practitioners, and researchers must acquaint themselves with the multi-faceted opportunities, challenges, and constraints of online resources and tools. The development of the capacity to make use of ICTs in the schools constitutes the rationale behind training learners. They will then be in a position to take advantage of ICTs at the school or university levels, and to have access to the wider field of knowledge reached through the new technological means. As pointed by Unesco in its most recent report on World Education (1998),

> In the education systems of the advanced industrial countries, computers are currently utilized mainly in three roles: first, the traditional one as a means of ensuring that students acquire a minimum level of computer literacy; second, as a means of supporting and enriching the curriculum; and third, as a medium for interaction between teachers and learners, between learners and between teachers. (p. 84)

The Unesco Report goes on to stress that it is with respect to the third of the three roles, "that the computer and associated communication technology could potentially have the most significant implications for conventional education." (p. 87). As teachers and learners have an increasing capacity to interact online in asynchronous and synchronous modes, leading-edge research points to the necessity for teachers to master more advanced pedagogies when meeting face-to-face with learners.

The authors suggest that the introduction of computers linked to other computers into school/university labs and classrooms is an event of major importance for the schools and universities throughout Canada. Referring to John Dewey on the value of theory (1929), this documentary review is meant to widen the range of attention of educational leaders, to enable them to see more relations and possibilities, and to widen their scope and ability to judge.

1. Definition of terms

For the purpose of this review,

online resources and tools are understood to mean the information and communication technologies (ICTs) applied to teaching and learning for the purpose of providing: 1) the flexible delivery of educational material (technology for the instructor), 2) the guidance and facilitation of the experience of the student (technology for the learner), and 3) the support of communities of learners (collaborative learning). "These technologies make it possible to provide access to world-wide resources; facilitate the accumulation and presentation of data; and enable communication, interaction, and collaboration among students and instructors to improve the practice of teaching and the experience of learning." (National Science Foundation (NSF), 1998, p. V);

effective use of online resources and tools is understood to encompass those pedagogies that take advantage of "applications that engage students with the material, illustrate complex systems or relationships, and encourage interaction with other individuals or teams. Ultimately, the technology tools should become transparent as they integrate the user in the process, enabling immersion in the learning level, and that, on an individual or community basis." (NSF, 1998, p. V)

telelearning is understood to mean the use, at school or at home, of multimedia computers networked to other computers for learning purposes (TL*NCE, 1995). Learners using computers networked together may of course communicate from one site to the other, using a variety of information sources.

computer-mediated communication (CMC) has been defined by Kaye (1991) in the following terms : "The use of computers and computer networks as communication tools by people who are collaborating with each other to achieve a shared goal, which do not require the physical presence or co-location of participants, and which can provide a forum for continuous communication free of time constraints" (p. 5).

learning with ICTs emphasizes the socio-cognitive impact of teachers and learners working in partnership with technology. Research results are understood to be "effects *with* " rather than "effects *of* " the computer. As pointed out by Salomon, Perkins & Globerson (1991), and re-emphasized by Salomon & Perkins (1996), this approach contrasts with the study of the effects of technology on learning and teaching. That shift from *learning from media* to *learning with media* in emerging technology research, is described by Hannafin, Hannafin, Hooper, Rieber, &

Kini (1996) in the following terms: "this research with technology focuses on how human processing changes in distinct, qualitative ways when an individual is engaged in an intellectual activity using the computer as a tool. Taken interactively, an intellectual partnership is formed between the individual and the technology; the resulting changes to cognition cannot be understood when the individual or the technology are considered apart" (p. 392).

This choice of concepts indicates that this review adopts an approach likely to document the effective uses of online technology, ranging from accessing online information to network-supported collaborative knowledge construction by students.

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2. Methodology

For the 1996-1998 period, the online search dealt with the contribution of new information technologies to learning and teaching in elementary and secondary schools and universities. The search was exhaustive and emphasized articles, reports, papers and book chapters meeting the criteria for scholarly publications. Although studies on distance education, libraries, and conference proceedings were excluded from the systematic search, some such articles were included to document specific points. Proceedings were judged to be of an exploratory nature which usually do not present final conclusions and findings, but some papers presented at conferences were included to support specific trends. Finally, a search using Internet search engines such as Alta Vista or Excite was also excluded since the volume of information retrieved would have be too large, many of the articles would not meet scholarly criteria and it would have be difficult to evaluate and authenticate the studies. However, online articles, reports, and papers meeting scholarly criteria were included. (See Appendix A, Methodological Notes.)

3. An organizing framework

The reviewed literature displays a mixed model of classroom uses of online resources and tools. This mixed model is more visible in the research on higher education because, for instance, the instructor puts course materials online while engaging in face-to-face and online conversations with the students. In the elementary or high school classroom, the most innovative and promising practices center around authentic problem-solving, inquiry-based learning, and collaborative knowledge-building. Most findings are concerned with context and process rather than content or outcomes. Thus, learning outcomes, as measured by standardized tests, are bound to vary greatly from study to study in these early stages of the use of online resources and tools.

This is also to say that currently issues of 'design' are prevalent with respect to the use of online technology in learning, and that research could be supported by a more direct 'design experiment' framework for vigorous discussions of the contexts and processes that ensure the attainment of the conditions of online learning. "It is important", stress Plomp, Brummelhuis and Pelgrum (1997), building on the evidence provided by Brummelhuis (1995) and Janssen Reinen (1996), "that decision makers understand that the integration of technology in education depends upon not one factor, but on interconnected elements that will vary according to the level of implementation of technology" (p. 468). Therefore, it was thought useful to identify models most likely to provide a fuller picture of the state-of-the-art regarding the use of online resources and tools.

3.1 Models of use for online technology

3.1.1 Two underlying perspectives: incremental change or transformative change

First, a distinction needs to be established "between technologies that extend or replicate the classroom model, and those that fundamentally change the instructional paradigm". The paradigm change involves reconfigurations of time and place for learning, but most importantly new ways for learners to collaborate and establish relationships with other individuals and knowledge objects. Bates (1996) goes on mentioning:

> Technologies such as one-way television and two-way audio, or video-conferencing, replicate the classroom model. These technologies are valuable where there are multiple sites within the same system, and insufficient number at a particular site but sufficient overall to justify mounting a course. They are also valuable for special events, when an outside expert or panel can be brought into one or more distance locations. However, learners are still time and place dependent when using such technology. ITV and videoconferencing then are at an intermediate point on the scale of accessibility. These technologies also have high unit costs compared to some of the other new technologies (see Bates, 1995, for a full analysis). (p. 6)

"Technology, used appropriately, can help the teacher and student restructure how the [elementary or secondary] classroom is organized, what topics are studied, and how students learn and are assessed", stressed Knapp & Glenn (1996, p. 13). As regards the university classroom, Norris (1997) suggested: "The world of learning we are experiencing today represents a misleading preview of the world five years from now.) Many of the current leading indicators () represent the way we "digitize" existing practices, rather than use technology to do things differently." (p. 4)

There is a growing number of teams of technology and content experts working at providing the classroom with educational materials that take advantage of the multimedia and interactive properties of computers. The products they create, usually on websites or CD-ROMs, are meant to engage the student in individual learning activities; some products are closely associated with basic concepts/skills or specific curricula, and some may include online activities (intranet or Internet).

The 1996 Documentary Review (Grégoire, Bracewell, & Laferrière) reported on Computer-Assisted-Instruction and Integrated learning systems providing drill and practice for remediation to structured curriculum and instruction; here, the computer is seen as a tutor, rather than a tool (see also Kulik, and Kulik, 1991). And there is some legitimate concern in the teaching profession that the use of such tutors may engender the de-skilling of teachers. One is well-advised to acknowledge, however, the rather naïve view of knowledge that resides behind this first perspective. As stressed by Harlow and Lamont Johnson (1998), who define epistemology as referring to the nature of how the mind processes and forms beliefs about the objects and events in our surroundings, "the idea that we form our notions of the world directly by letting them seep through our senses and mind is considered to be the position of naïve epistemology". (p. 15) (see Miller's reference to Popper, 1983, on this issue; see also Novak & Gowin, 1984). But one must also acknowledge that education systems are built in their entirety on such an epistemology, and that any departure from it is bound to go against the grain at one point or another.

Hollenbeck (1998) observes that the computer is now given a second chance ? this time as a tool rather than as a tutor ? and with the hope that it will help modify the learner's schooling experience: "Coupled with the rhetoric of school reform, the Internet-driven curriculum is seen as a place for students to create meaningful knowledge on their own, using an environment full of experts waiting to be interviewed and vast amounts of information ready to be mined." However, as he notes, "most of the new promises [being made] remain based upon the computer delivering information to the student" (p. 38). This observation is also made by the RAND Corporation which looked (Glennan, 1998) at the first two years of the New American Schools Initiative by making case studies of 40 schools in seven of the participating districts. RAND concluded that buying the technology, plugging it into a school, and thinking that things will improve is not enough. The study stressed that much of the improvement depends on the schools and the districts themselves.

Maddux, Johnson, and Willis (1997) distinguished two different kinds of computer use in education: Type I applications, "which make it easier, quicker, or more efficient to teach the same things in the same ways we have always taught them", and Type II applications, "which make available new and better ways of teaching". (Quoted by Harlow, and LaMont Johnson, 1998, p.18). The review team associates the latter with the perspective of the teacher as a reflective practitioner, the one dominating today's literature on teachers' professional development.

As the author of *The Reflective Practitioner* put it (Schön, 1983), the teacher must be "attentive to patterns of phenomena, skilled at describing what [he or she] observes, inclined to put forward bold and sometimes radically simplified models of experience, and ingenious in devising tests of them compatible with the constraints of an action setting" (p.322). This perspective was the one adopted by the TL*NCE research team on educating the educators, studying new pedagogies supported by telelearning technologies. Here, the effective use of online resources and tools for teaching and learning purposes is a matter of constant deliberative professional judgment on the part of the teacher. The computer is used as a tool, supporting the teacher in his or her practice of advanced pedagogies.

The assumption of the Review Team is that in order to meet the expectations of a knowledge society, the teaching profession should rely on the following approach: on the one hand, the professional teacher shall facilitate students' access to online resources and tools, and provide guidance to inquiry-based learning, and collaborative knowledge-building; on the other hand, he or she shall use highly interactive tutorials to engage learners in individual or cooperative learning tasks, thus allowing him or her to interact more at length with a student or a group of students in order to identify misconceptions or deepen students' understanding of some subject matter.

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3.1.2 The main constituents of the teaching/learning exercise: the four basic elements of the organizing framework

Effective uses of online resources and tools should improve the teaching/learning exercise. The Review Team borrowed Schwab's (1969) main constituents (commonplaces or dimensions) of the educational situation - "someone teaching something to someone in a given context" - in order to provide an organizing framework within which to consider the results of the literature search. In addition, the review team elaborated on each of Schwab's four constituents (teacher, content, learner, and context) along a continuum that is relevant for treating the role and effects of online technology in the classroom:

a) The teacher (continuum: from transmission to facilitation). The "someone" teaching may be a teacher in front of the class giving a lecture with the support of a data projector, or structuring team work for effective project-based learning. The "teacher" may also be on line such as in an EMG lesson, or an online expert (for instance, a published author) coaching a student into writing (Writers in Electronic Residence Program,WIER, see Wideman and Owston, 1997). The continuum highlights the role of the teacher, in that at one extreme the teacher may be primarily concerned with delivering content information to the learner, while at the other extreme, he or she may be concerned primarily with facilitating activities of the learner that result in learning.

b) The content (continuum: from "pre-organized" or "canned" to "constructed"). The " something " that is being taught may be, at one extreme end of the spectrum, an already existing fact or body of knowledge, it may be a theme or a project that is actively being built up by the learner, and at the other extreme scientific literacy in a Schools for Thought type classroom where grade four students began with a sustained investigation of the Madagascar Giant Hissing Cockroach and progressively moved into an investigation of adaptation, evolution, etc. (Caswell & Lamon, 1998).

c) The learner (continuum: from limited access to online resources to high access to online resources). For the purposes of this review, the learner is clearly in the limelight with respect to the degree of access he or she is able to achieve to online resources in the classroom or school. Thus, this constituent includes both the technology that is at the learner' disposal and the learner's competence in using it. At one end, the learners might be in an elementary classroom going to the computer once a week to learn keyboarding, and later on, visiting a few sites as part of an electronic fieldtrip; at the other end, the learners might be in a PROTIC classroom where every junior high learner has a laptop networked to a server which provides intranet- and Internet-connectivity. The significance of that focus will be seen below when we integrate possible combinations of the constituent dimensions.

d) The context for the use of online resources (continuum: from low external support for online use to extensive external support for online use). As in the case of the learner constituent, the context is considered in a very focused way for the purpose of this review. What we are concerned with here is to what extent the situation of online use includes a champion (or educational leaders) capable of mobilizing resources, bringing together stakeholders (teachers, administration, parents) who can support classroom activities, and acting as a resource person to the teacher outside the classroom. We are also concerned with policy and administrative practice. And we include support programs that may involve students such as the Information Technology Management Program (Willinsky & Forssman, in preparation) or colleagues working in different schools (online learning communities).

The four elements or dimensions outlined above serve a number of purposes in this review. First, the dimensions define a space onto which we can map the research literature that we have reviewed. Thus, our overall analysis is based on what are considered the four key constituents involved in the teaching/learning exercise: the teacher, the content, the learner(s), and the context. Among the constellation of possible combinations of those constituents, depending on their individual characteristics, the two extreme combinations were retained and used to identify the following models of use:

	TCLC -	**TCLC +**
Teacher	transmitter	facilitator
Content	pre-organized	constructed
Learner[s]	low access	high access
Context	limited support	extensive support

Most current classrooms would lie toward the left ends of each continuum: 1) the teacher is a transmitter of knowledge rather than a facilitator of learning, 2) the content is pre-organized by the teacher or 'canned' on a CD-ROM rather than constructed by the learner; 3) the learners have low rather than high access to online resources and tools; the context offers the teacher and his or her classroom a limited rather than a high level of support for new initiatives and resources. This model of use, called (TCLC -), which stands for each of the first letters of the four basic constituents, is being given here the notation minus (-) in order to point to low levels of interaction between the teacher and the learners, of constructed content if any, of access to online resources and tools, and of support from the external context.

The **TCLC - Model of use** or any of the three other variations in which one of the four constituents is at a low level is by far the most frequent situation at this point in the integration of information and communication technologies in education. In contrast, the overwhelming thrust of research initiatives within the socio-cognitive psychological perspective would seem to be directed towards the opposite ends of each continuum: teacher/facilitator, content/constructed, learners/high access, context/extensive support (**TCLC + Model of use**). Here, the teacher primarily facilitates student learning, the curriculum content is largely constructed by the learners, the learners have free access to online resources, and the context supports the use and expansion of the resources.

The usefulness of these constituents can be seen when one creates clusters of extreme dimensions in order to highlight the relationship between possible combinations and performance (learning) outcomes:

- one extreme combination occurs when the teacher transmits a ready-made content to a classroom where student have access, for instance, to one computer with a dial-up access (28 800K) twice a week. That combination, although somewhat stereotypic, characterizes the traditional classroom;
- the other extreme combination occurs when the teacher as a facilitator, works with learners who are building content through the use of online resources, and that, in a context which provides support for such online use. That combination

is exemplified in efforts such as the Knowledge Society Network: elementary school learners investigating flying in a number of theoretical and practical dimensions, and engaging in knowledge-building dialogues with undergraduate science students, and other participants at different levels of expertise in the domains (Scardamalia, and Bereiter, 1996).

The framework also makes it possible to classify other possible combinations of online uses which have been reported in research on online technology in the classroom. One such combination is the situation of having access to experts through online resources in which the expert (as the teacher constituent) is primarily transmitting content to a learner who has access to online resources. The Writers in Electronic Residence Program (WIER, see Wideman and Owston, 1997) is an example of such a combination. The context in this situation is highly striking - one of the principal concerns of the teachers and researchers involved in the WIER Project is the establishment of information technology resources that ensure an easy and timely response of the experts to student requests for feedback (R. Owston, personal communication, 1998). Another possible combination is the situation of the learner having access to online resources, which are used primarily to receive content from external databases. The role of the teacher is to ensure that the information received or produced is accurate; thus the context is one in which access to online resources is supported to that extent. An example of this combination can be found in Saye (1997), who interviewed secondary school teachers and students on their orientation and attitudes to the use of online resources. In Saye's apt metaphor, the majority of both teachers and students were 'accidental tourists', viewing online resources as being another inevitable source of information to be accommodated in the customary activities of teaching and learning in the classroom.

Different combinations within that framework can be seen as setting the conditions for the establishment of new and different classroom practices of teaching and learning. For example, the situation ? in which the teacher acts more as a facilitator, the content is more constructed, and the student is in a position to access online resources ? provides the conditions for effective collaborative learning in which students and teachers exchange roles, acting at different times as resources, collaborators, and audiences for the demonstration of learning (see Wolfson & Willinsky, in press). These combinations also provide the conditions for use of more authentic learning tasks, they enable students to move beyond the classroom and engage outside resources in their learning. Thus, points along the continua of the constituents create a synergy that supports major change in classroom teaching and learning practices.

An important point is that this framework simply outlines the range and possibilities of use (including non-use) of online resources in the classroom. It does not indicate which combinations are more desirable or conducive to learning. This is because learning, and the use of that learning by students, are highly situational. Sometimes the direct transmission of information, as the learning of conventions such as "drive on the right side of the road", is the best way to ensure learning. The value of the framework lies in its coordination of online resources (as seen in learner access), teacher role, content manipulation, and context of online resource support: What we should seek to achieve in the online classroom is the potential for implementing the various teacher/content/learner/context combinations most appropriate to particular student learning. Students would not be well served by being online, constructive, and facilitated all of the time. However, the anticipated goal is the classroom that can realize all the possibilities of these four constituents, as appropriate for the learning needs of the students.

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3.2 High access to technology and teacher professional development: a rare combination of events

The networked *classroom* that is, a classroom where learners have an easy access for learners to computers linked to an intranet and the Internet - is a very exceptional reality in K-12/13 and post-secondary education systems in Canada. Universities, colleges, and schools may be connected to the Internet, but rare are the classrooms using online resources and tools for learning purposes. Most of those having access are still in the process of learning *about* computers and information and communication technologies rather than *with* such tools to generate products and ideas. For instance, a class of students would go to the high school/college/university computer lab(s) at specific times for hands-on activities. Or the teacher would borrow a data projector to support a presentation or demonstration. Analyzing the uses made of computers in schools, Unesco, however, concludes (1998) that "it is clear that computers are now beginning to be used by the schools for more things than just computer literacy" (p. 81). The evidence provided includes the Third International Mathematics and Science Study carried out in 1994-1995 (p. 85).

In its most recent report, Psychometrics Canada Ltd. just completed a study (Macnab and Fitzsimmons, 1998) which shows higher achievement test scores in mathematics. This comprehensive, year-long study involving 1,184 students in 14 secondary schools found that students using computer-based courseware achieved higher test scores and higher levels of comprehension than students using traditional textbooks and classroom techniques. Approximately half of the students (the "test group") used a set of computer-based courseware developed jointly by the governments of Alberta, British Columbia, Manitoba and Saskatchewan and educational publisher ITP Nelson. The other half (the "control group") used standard math textbooks. Outcomes were measured at the end of the school year by administering the Alberta Education Grade 9 Mathematics Achievement Test (based on the common math curriculum used in the western provinces). Significant differences in achievement in favor of the TLE group (students who learned with the computer-based courseware called The Learning Equation Mathematics, TLE Math, http://cgl.nelson.com). Key findings included: 1) A higher percentage of students using TLE Math scored 50% or higher on the final math test (65% vs. 41%) and more TLE students achieved an 80% grade or higher (19% vs. 5%); 2) The TLE Math method led to improvements in tested content areas, including knowledge, skills, number, pattern and shape; 3) 92% of the teachers thought that students' time on task had increased.

This is a good example showing how well-thought out of and well-designed "canned" content may lead to better student achievement. However, the results raised questions as to what other factors (related to the teacher, or to the learner) might have played to explain why in some schools (context) the differences between TLE and NON-TLE groups were significant and not in others.

The 1996 Review stressed a number of studies which reported better learning in various subjects and various skills and attitudes developed, including higher order intellectual skills such as reasoning and problem solving ability, learning how to learn, and creativity. These studies came from specialized situations in which researchers based in universities and teachers in the classroom were collaborating on research on the effective use of information technologies in instruction. Since the publication of that Review a major report has since documented the effective use of these technologies in the general educational system. The Educational Testing Service (Wenglinsky, 1998) analyzed a national database of student test scores, classroom computer use, and other information, for Ed Week's *Technology Counts '98,* and found that eighth graders whose teachers used computers mostly for "simulations and applications" - generally associated with higher-order thinking- performed better on NAEP than students whose teachers did not. Meanwhile, 8th graders whose teachers used computers primarily for "drill and practice" - generally associated with lower-order thinking - performed rather poorly. Gains were greater at the middle school level than in elementary school. Among 4th graders, students whose teachers used computers mainly for "math/learning games" scored higher than students whose teachers abstained. The research found no association, positive or negative, between 4th graders' scores and either simulations and applications or drill-and-practice. Again, these results call for further investigation to determine the pedagogical practices and social and cognitive factors associated with enhanced performance. See http://www.ets.org/research/pic/technolog.html

These learning outcomes, especially in a subject matter such as mathematics, are likely to have a convincing effect on teachers. Because the public demand stands for learning improvement, professional educators are interested in the process-related factors that lead to such outcomes. In the 1996 Review, the effective use of new technologies in facilitating student learning and performance was linked to the following prerequisite: that participants have the knowledge and skill to use the technology (technological and pedagogical knowledge and skill). Process-related outcomes were identified at the time as made up of: 1) the student motivation (greater spontaneous interest, time and attention devoted to learning activities), 2) the relationship of students to knowledge (that is, how students approach knowledge and incorporate it into what they already know), and 3) the cooperation among students in the same class and among students or classes in different schools, near or far, for the purpose of making them more aware of other realities, accessing relevant knowledge not strictly defined in advance, and executing projects with a genuine relevance for the students themselves, and possibly for other people. It was found that such students tend to develop a spirit of research, as demonstrated by the search for more extensive information on a subject, a more satisfying solution to a problem, and a greater number of links among various pieces of knowledge or data, leading to better integrated and better assimilated learning achievement (see the seventh observation of the 1996 Review: The potential for simulation, virtual manipulation, rapid merging of a wide variety of data, graphic representation and other functions provided by the new technologies contributes to a linkage of knowledge with various aspects of the person, thereby ensuring more thorough assimilation of the many things learned).

As access issues with respect to online technology become resolved (learning *about* technology), new pedagogical possibilities emerge that teachers have to explore in order to arrive at satisfying results to be effectively measured by student learning outcomes. Flexibility of use, that is, of a variety of combinations ranging from the **TCLC** - Model of use (*teacher/transmitter, content/canned, learners/limited access, context/limited support)* to the **TCLC+** Model of use (*teacher/facilitator, content/constructed, learners/high access, context/extensive support)* is unlikely without professional development. A research component may be added in order to document the exploratory process and identify early results. Let's now turn to studies that capture such experiments. Some of them call for nothing less than changing roles in education as electronic connectivity progressively becomes a reality (see Berge, 1998).

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4. The emerging trends in the renewal process

The emerging trends (propositions) are drawn from research conducted in both the K/12-13 and the post-secondary sectors. The results as regards the K-12/13 sector are mainly process-oriented, whereas those of the Higher Education sector include more outcome-oriented results. Approximately 100 studies from each sector are included from among 200 to 300 reviewed per sector. Propositions concerning the higher education level only appear in point form in this documentary review, but are substantiated by hyperlinks to an annexed document, made of rich descriptions of each one of the emerging trends (conceptual and practical aspects) in the networked university classroom using online resources and tools. Trends related to the K/12-13 sector are complete in and of themselves, hyperlinks being made to a number of relevant online documents.

4.1 The K-12/13 networked classroom, and its context

The Review Team relies on the demonstration conducted in the summer of 1996 looking into the full spectrum of use of the latest educational technology to enter the classroom, online resources and tools on multimedia computers. In the networked classroom (or computer lab), students have the opportunity to engage with a subject matter, either individually or in small groups, in a number of ways. Information may be accessible in a variety of formats (CD-ROMs, authoring software, specialized websites, etc.). Highly interactive multimedia or hypermedia activities are not yet widely distributed. Thus, online activities that involve the use of resources and tools put on an intranet, or accessible through the Internet are mainly for information and communication purposes (see Santaro, 1998, for a fuller description of an online classroom).

K/12-13 classrooms did not await the arrival of the WWW to engage in online activities. In the fall of 1996, Trentin was in a position to outline three teaching contexts in which telelearning activities can effectively help the educational process at various levels:

> a) Plain utilization of the network for communication, that is, as a powerful tool for navigation through distributed information and for interpersonal communication.
>
> b) Using computer networks in support of educational activities that can be conducted with or without the network (e.g., correspondence) but which in this way gain new educational and cognitive momentum, as well as producing greater motivation and involvement.
>
> c) Learning activities based on specific approaches which are strictly dependent on the use of [telelearning activities] and could not exist without the network. (p. 11)

This documentary review deals with each one of these contexts, but does not distinguish them per se as its focus is narrowed to the networked classroom. With respect to the last teaching context, Trentin observed that "telematics is not only a resource that adds value but is rather a key factor in the adoption of new methods supporting the teaching/learning process". (p. 11). The 1996 Documentary Review came to the conclusion that the teacher's pedagogy is the key factor in the contribution of ICTs to learning and teaching.

The studies reviewed in 1996 were for the most part conducted in the context of individual classrooms. The broader context, as characterized by the presence or not of champion(s), is this time being considered in an attempt to extend the review beyond the individual variable level to reach the policy level. The RAND study (Glennan, 1998) on the New American Schools concluded that schools differed greatly in a number of important factors: for instance, in their ability to implement reforms, the design teams varied widely in their capacity to help schools, and districts offered varying levels of support. So, the organizing framework suggested here, should include educational leaders whose practice lies outside the classroom, working at the school, the school district or at the government levels. They too espouse particular pedagogical approaches which have an impact on what is going on in the classroom or in the measurement of student achievement.

Policy makers wondering if they are making the right decisions as regards school and classroom connectivity are also likely to be aware of other educational trends such as the following ones: 1) more emphasis is put on achievement, 2) changing relationships between schools and their communities, and 3) educators are forming partnerships to improve teaching and learning. The first trend is often pursued with an orientation toward the past (the back-to-the-basic solution), the second with an orientation to the present (the awareness of student diversity, and a communal approach to face educational challenges), and the third with an orientation to the future (lifelong learning skills for all).

For educational leaders that are mobilizing and reallocating resources to provide the conditions (access, connectivity, professional development, and content development) for the use of online resources and tools, better student learning is a must. But, as stressed by Dede in the ASCD Yearbook 1998, better outcomes are often associated with higher scores on conventional measures of achievement designed to assess a narrow range of knowledge (p. 211). When one looks at evidence of improved learning results on a rather large scale, he or she may turn to the study of The Center for Applied Special Technology (CAST). Follansbee, Hughes, Pisha, and Stahl (1997) looked into how online communications may improve student performance. This controlled study demonstrated that students perform better on measurements of information management, communication, and presentation of ideas, comparing 500 students in fourth-grade and sixth grade classes in 7 urban school districts in the U.S. See http://www.cast.org/publications/stsstudy/

In 1998, the Unesco World Report concluded that there is a dearth of rigorous research findings, demonstrating clear learning gains over conventional classroom processes, that is, with the learning that is now becoming more and more useful in active life outside the school (p. 93). Such findings were also found to be scarce in Ed Week's Technology Counts Report (http://www.edweek.org/sreports/tc98/intro/in-n.htm). In the national study that Wenglinsky (1998) conducted in the U.S., he also found improved attitudes towards learning math, greater ability to self-manage learning, and improved work habits, thus confirming on a large scale results already identified in experimental studies. Given findings concerning positive outcomes initially seen in specialized research situations and then confirmed in more general and representative educational settings (see Becker, Anderson, Riel, and Ravitz, in press), we can anticipate that this pattern will be seen also with respect to the learning outcomes that can be supported by access to online information technology. We now turn to the new research results (1996-1998), as we identify specific emerging trends which point to the significance of the changes one may have to make in his or her pedagogy in order to effectively use online resources and tools.

4.1.1 Trend 1: *Higher levels of control by learners are called for as classrooms are getting more online.*

Access to hypermedia and hypertext opens the online classroom to broader and enlarged information sources, curricula, methods, and intellectual artifacts. Once online resources are found, further access may be tightly controlled or open-ended. "Whereas traditional approaches to computer-based learning have been rooted in behavioral learning principles, contemporary approaches are more often rooted in cognitive learning theories." (Hannafin, Hannafin, Hooper, Rieber, & Kini, 1996, p. 391). The design strategies which maximize the learning potential of open-ended environments put the locus of control on the learner's side, thus enabling the learner to engage much more in the construction of content. This in turn makes student learning strategies much more significant in the classroom. Students who not only are made aware of, but who take control of, those technologies must be able to plan, choose, inquire into topics, solve problems, monitor their progression, and evaluate results.

The online classroom could get involved in online activity in most academic areas (environmental studies, mathematics, science, language arts and social studies). In such instances, curricula are no longer planned by teachers with limited scope (see the textbook), but geared to include up-to-date information, a procedure more likely to take into account students' interests. The Internet makes possible a greater range of learning and teaching activities (see Harris' list of activities, 1998).

Studies on simulation or visualization technologies, likely to help students to learn complex systems in more concrete ways (Pea, 1992) as well as studies on semantic networks (online concept maps), provide informative glimpses into upcoming possibilities for teaching and learning. REALs (rich environments for active learning) are, according to Grabinger (1996), "much more comprehensive and holistic than individual computer applications" (p. 668).

It is to be understood that, until recently, the 'release of agency' by the teacher to the student was not highly valued by various social and educational actors. It took numerous orientation documents, one of the latest being the Delors Report (1996), to articulate in a knowledge society, a rationale as to the necessity of the learner being more active and collaborative. Yet, many parents, journalists, and educators are not aware of that emerging dimension.

In the meantime, there are teachers who innovate in the production of desk-top educational materials, sometimes involving their students as designers or co-authors of data bases (Scardamalia and Bereiter, 1996), or as project collaborators (see Ward and Tiessen, 1997; Tiessen and Ward, 1998). Some publishers and telecom companies market their educational activities.

The debate over the utility of the information accessible on the Web is likely to remain very much in the limelight until society comes to terms with issues of authority and control (autonomous and creative vs. obedient students, meaningful vs. easy and playful learning, learning from a complex versus linear information structures, see Shapiro, 1998).

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4.1.2 Trend 2: *Learning situations become more realistic and authentic as classrooms are getting online.*

Both access to online resources and in the learners' increasing engagement in the construction of content is conducive to better and more authentic learning situations in the classroom. For instance, in environmental education, students are using geographically distributed and interconnected virtual worldwide libraries of documents. At the present time, a limited number of well-controlled studies of learning in the online classroom are available. This is, in part, because access to both information technologies and online resources remains a challenge for the majority of schools (Hack and Smey, 1997; Levin and Thurston, 1996). Results from evaluative studies of the Writers in Electronic Residence (WIER), a Canadian Program that connects professional authors with classrooms, show that students develop enthusiasm for creative writing and write with a sense of audience and maturity far beyond their teachers' expectations (Wideman and Owston, 1997).

The emerging evidence from the small number of experimental studies from online classrooms shows enhancements in learning of two types: the first has to do with providing Type I resources for the kinds of learning that already are emphasized in the classroom. For example: the increased learning about weather and climate conditions by middle school students using online resources and communication (Bonk, Hay, and Fischler, 1996), and greater learning about civil rights by elementary students following Internet use as compared to the performance of the control classes (Follansbee, Hughes, Pisha, and Stahl, 1997). The second learning type has to do with providing Type II resources for new or not presently emphasized types of learning in the classroom. A striking example is secondary school students working more independently and taking more responsibility for their learning when using online resources without the help of a teacher in their immediate school (Adnanes and Ronning, 1998).

There is of course a wealth of descriptive evidence on the beneficial effects of online collaboration with other students and with experts and other resources beyond the classroom, evidence which began to be collected in the 1980's when students started to gain access to wide area computer networks. Recent additions to that evidence include Cohen (1997), Bruce, Carragher, Damon, Dawson, Eurell, Gregory, Lauterbur, Marjanovic, Mason-Fossum, Morris, Potter, and Thakkar (1997) on science education, Schofield, Davidson, Stocks and Futoran (1998) on second language learning, Keisler (1997) on a range of educational uses of the Internet. The nature of this descriptive evidence can be seen in a comment by an upper elementary school student participating in the Bruce et al. (1997) study:

> Instead of just looking, you know, at the page in the textbook; we can look actually on the Internet at the pictures of the actual egg and we get to control it. And we get to send in our discoveries and have our questions answered like faster, I suppose, and from actual, you know, people like that are specialized in what we are doing. (p. 82)

This comment reflects both student access to online resources and construction of content. In the long run, it will be such reactions by students that convinces both educators and the public that online technologies have a significant role to play in education.

4.1.3 Trend 3: *Online resources boost student interest and motivation in the classroom through a greater diversity of learning goals, projects, and outcomes.*

One of the most consistent outcomes of placing information technologies in classrooms and ensuring that students have access to them has been that student interest in, and satisfaction with, schooling increase (see US Congress, Office of Technology Assessment, 1995, pp. 65-66). The same outcome is seen in the online classroom, where a more positive reaction to school has been found across diverse groups of learners. For example, in Schofield et al. (1997) almost all of the 28 elementary and secondary teachers participating in the Common Knowledge Internet project reported greater student interest and participation in classroom activities. Similar findings are being reported for 'at risk' learners who are cut-off or alienated from school activities because of physical or learning disabilities, or social differences and problems. The use of online resources to support these special populations is in its infancy. The recent review by Woodward and Rieth (1997) of the use of technological support for special education students made no mention of online technologies. However, current work with these technologies includes support for deaf students (Johnson, 1997; Luft, 1997; Weber, 1997), for blind students (Kapperman, 1997), for students with learning disabilites (Delzell and Hamill, 1996; Fargen, 1996), for intellectually gifted students (Bulls and Riley, 1997), and for students experiencing social difficulties at school (Diggs, 1997; Kinney, 1997).

This motivational effect may seem to be a 'soft' outcome of placing technology in the classroom, since the major benefit that one would like to see is an increase in learning on the part of students. In the face, however, of drop-out rates of 30-40% at the secondary level, increasing student motivation to stay in school is a major issue. Moreover, we know something about how this increase in motivation arises: it is not limited to the allure of fashionable technology providing a general motivational boost (although a Hawthorne effect may be present initially), but favors access to information technology in the classroom, including online technology, leading to a greater diversity of experiences and learning goals in the classroom. This in turn makes the classroom a more interesting environment that appeals to a wider range of students (Bulls and Riley, 1997; McDonald and Ingvarson, 1997; Murphy, 1997).

4.1.4 Trend 4: *The successful online classroom combines information technology with appropriate pedagogy.*

The construction of content gives rise to the different types of learning situations in the classroom. Collins (1991) reported decreases in teacher-led activities, and Kerr (1996b) a decrease in the amount of frontal instruction and a move toward more project activities and independent learning. As far as information and communication technologies (ICTs) are concerned, their effective uses in the classroom must be accompanied by an appropriate instructional approach. This appears to be particularly the case for more open-ended uses of online technologies such as information searches and electronic interaction among students. For example, studies of students conducting Internet searches have shown that they are more successful when search procedures are structured either through modeling by the teacher or through scaffolding using templates to guide the search (Reed and Wells, 1997; Schacter, Chung and Dorr, 1998). Similarly, studies of students using computer mediated communication to do problem solving and other learning tasks have shown that the use of templates or texts to guide interaction produces more effective communication between participants (Baker and Lund, 1997; Tergan, 1997; Tiberghien, and De Vries, 1997). It is not always the case, however, that the appropriate pedagogical approach involves greater external structure. Adnanes and Ronning (1998) found that their secondary school students worked more independently and took more responsibility for their learning in an online course when they did not have the assistance of a teacher in the immediate classroom.

The importance of a pedagogical approach (Bonk et al., 1997; Mergendoller, 1996; Owston, 1997) that is appropriate, and the large number of possible combinations of approaches with online learning tasks, has led to the call for research on the design of online learning environments for the classroom (Hannafin, Hannafin, Land, and Oliver, 1997; Jonassen, 1997).

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4.1.5 Trend 5: *The classroom is extended to online learning communities with*

the potential to support or even challenge the locally-established curriculum.

In connected classrooms (whether this connection is local or remote), new interaction patterns are born. Resources for learning expand beyond the teacher and textbook. Learners acquire broader audiences for their constructions and outputs. The capability of presenting and manipulating outputs facilitates collaboration with other learners. For instance, part of the student to student interaction may be structured around collaborative projects with faculty and students at distant schools. At times, experts and other community members are included. As pointed out by Davis (1995), the timeliness of the communication remains in the attention span of the classroom (p. 591). Over the last ten years, researchers engaged in collaborative projects with school teachers, and developed online communities of practice (mostly in environmental studies, and in the math/science content areas; see Riel, 1994). They contributed to the re-emergence of the project-based learning approach as they structured projects around specific inquiries, scientific expeditions, services, or deliverables (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, and Palincsar, 1991; Marx, Blumenfeld, Krajcik, and Soloway, 1997; see also Grégoire et Laferrière, 1998).

Cooperative learning is a practical approach which structures classroom activities through specifically assigned roles, tasks, and procedures. The use of computers to support cooperative learning was compared with competitive/individual approaches by Johnson and Johnson (1996). They concluded that computer-assisted cooperative learning promotes (a) higher quantity of daily achievement, (b) higher quality of daily achievement, (c) greater mastery of factual information, (d) greater ability to apply one's factual knowledge in test questions requiring application of facts, (e) greater ability to use factual information to answer problem-solving questions, and (f) greater success in problem-solving (p. 1032).

Collaborative learning moves the classroom beyond cooperative learning, promoting less structured but more active dialogue between participants seeking to understand and apply knowledge (notions, concepts, principles, and techniques). The process of progressing in the understanding of a question or a theme of inquiry has been called knowledge building (Bereiter, and Scardamalia, 1993; Harasim, 1990).

Hativa and Lesgold (1996) studied competition and collaboration in integrated learning systems (ILS), and found that the social structure of classrooms was remarkably stable and hence an important factor in learning outcomes. Extending their findings to network technologies, they predicted that effects of the technology would be diverse, with some classrooms forming extended learning communities that would support students working towards shared learning goals, while other classrooms would not succeed, to the detriment of student learning and self-image (p. 168).

Canadian researchers are designing, field-testing, and implementing networked-based collaborative tools which have shown increasingly positive results on student learning. These initiatives include CSILE (Computer-Supported Intentional Learning Environment), WebCSILE, and Knowledge Society Network (Reeve, and Lamon, 1998; Scardamalia, and Bereiter, 1996), Studio A (Wolfson, and Willinsky, in press), Virtual-U (Harasim, 1997) and Virtual Campus (Paquette, 1995). In the United States, there are also initiatives, including COVIS (Pea, 1992) and the Multimedia Forum Kiosk (Linn, 1996).

As demonstrated by the Schools for Thought research projects (Brown, 1997a; Scardamalia and Bereiter, 1996, http://csile.oise.utoronto.ca ; McGilly, 1994; Cognition and Technology Group at Vanderbilt, 1993), the more recent CSILE projects (Scardamalia and Bereiter, 1996), and now the Knowledge Society Network (Scardamalia, Bereiter, and Keating, TL*NCE Proposal) support distributed cognition in elementary classrooms, while requiring the use of advanced constructivist learning. Progressive discourse is encouraged; learners become designers and experts. Learning community goals are highly centered on knowledge advancement. But the social interaction on the Web is manifold. Social dynamics must be channeled for interest groups to become learning groups (see GlobalLearning website, http://www.globallearning.com/ ; I*Earn website, http://www.iearn.org ; see also the Knowledge Integration environment developed at Berkeley University, KIE, http://www.kie.berkeley.edu/KIE.html) that activate and learn from shared representations.

Looking at the effects of social context when learning with computer technology, Lou, Abrami and Muni (1998) conducted a number of meta-analyses on relevant research studies in an attempt to synthesize the literature on the influence of small group versus individual learning with computers. They came to the conclusion that on average small group learning with computer technology has positive effects on group task performance, individual achievement, and attitudes toward collaborative learning. Hollenbeck (1998) reported on a more democratic learning environment being created with the support of networked computers.

Keeler's (1996) positive qualitative evaluation on the learning environment of the use of networked computers in the elementary classroom led her to suggest a six-step model for creating a community of learners through the implementation of computers: 1) involve teachers at the beginning, 2) form building-level teams, 3) train everyone involved in the project ; 4) have adults model their own learning process to children in order to highlight the importance of lifelong learning, 5) involve parents in the classroom, 6) provide time for everyone to share their successes and learn from one another (p. 342).

Now, with respect to **the contribution of online resources and tools to teaching,** the current review points to the following trend:

4.1.6 Trend 6: *The education of educators is broadened to include just-in-time and/or collaborative learning.*

For professional teachers to meet the expectations of a Knowledge Society, access to and use of better technology, that is, multimedia computers linked to other computers, is thought to be of some help. An historical look at the contribution of technology to education shows that other technologies have made such contributions in the past: the alphabet, the book, the blackboard, the overhead projector, the video projector, the computer. It is the assumption of the Review Team that teachers, like other professionals, need better technology and to make better use of technology in order to accomplish a task of an ever growing complex nature.

Though scientific evidence was even more scare in 1996 than it is today, the relationship between knowledgeable teachers and improved learning was already discernable (see Review). December (1994) pointed to the possibilities of teachers using the Internet for professional development (ProD) activities such as publishing on the Internet. The very fact of making information available online to other teachers about ones' own practices as a teacher is reflection on action, that is, a most essential ProD activity. As reported by Maring, Wiseman and Myers (1997), Anderson-Inman began a Technology Tidbits department in the *Journal of Adolescent and Adult Literacy* in October 1995 "to open a window (...) onto ideas for using technology in ways that support your goals as a teacher (...) so that [teachers will] be better informed about the potential that technology brings to the teaching and learning process (...) [and] will want to try more" (p.197).

Some educators are keenly aware that students' accessibility to information through the Internet must be channeled in proper ways (see Collis and Knezek, 1997). After a 4-year period of applied technology-enhanced instruction in the province of British Columbia, Woodrow stresses (1998) the importance for educators, including educators of educators, " to realize that the vast database in all areas requires public school students to have available the technological means of data access as well as the means to understand accessed information" (p. 7).

Computer literacy is still, however, a major problem for preservice and inservice teachers (see Larose, Lafrance, Grenon, Roy, & Lenoir, 1998; Roberts & Associates/Associés, 1998). The gap between the ones that have and the ones that have not the basic skills is highly perceptible in the teaching profession, whether at the entry level or later in one's career. Yet, much progress has been accomplished over the last four years, and the group of early adopters has reached a critical mass, as demonstrated by the number of preservice students having an e-mail address, and access to a networked personal computer.

Laferrière (1997) developed the following tentative ProD model for the integration of information and communication technologies (ICTs) in the classroom: 1) the awareness of the network phenomenon; 2) the mastery of access to online resources and tools; 3) the exploration of new possibilities for learning and teaching; 4) the establishment of new classroom routines; 5) the involvement of learners in project-based learning; and 6) the pursuit of collaborative knowledge-building.

Proper support must be provided at the school environment for teachers to integrate ICTs in their classroom activities (Adelman,and Panton Walking-Eagle, 1996; Maddin, 1997): peer coaching, including visits to classrooms using ICTs to assist their learning community activity, walk-in clinics, student assistance, and reflective activities. The Benton Foundation Report (1997) insisted on the necessity to build a "human infrastructure", along with an electronic one (computers and wiring).

There is now a plethora of interactive websites inviting user feedback, and participation in discussion forums. Teachers have had the possibility to join virtual interest groups, and learning communities for nearly a decade (Bull, Harris, Llloyd, and Short, 1989; Meadows, 1992). They are initiated by teacher associations or unions (e.g., Ontario Teachers Federation), university professors (e.g., Leach, 1997), units (e.g., Learning and Technology Group, McGill U), and research centers (e.g., Centre de recherche et d'intervention sur la réussite scolaire, CRIRES, Université Laval).

The number of preservice and inservice teachers using the Web for preparing lessons and courses is growing. Besides searching for information, teachers are also using the Web for communication and collaboration purposes (for instance, the Education Network of Ontario (http://www.enoreo.on.ca); TACT (Technology for Advanced Collaborative Teaching, see Breuleux, Laferrière, and Bracewell, 1998, http://www.tact.fse.ulaval.ca ; Project E.L.I.T.E, Gibson and Hart, 1997; De Carlitz and Zinga, 1997; PiVIT Project, Soloway, 1996; Collis, 1996).

As pointed by Soloway (1996), quoting John Richards of BBN in Cambridge, technology is the Trojan Mouse (p. 14). It comes into a classroom and there is a flurry of activity surrounding the technology; technology precipitates and enables teacher change (Apple Classrooms of Tomorrow, ACOT, see Haymore Sandholtz, Ringstaff, and Dwyer, 1997). This is also one of the key observations of the TeleLearning Professional Development School Project (TL*PDS), of which the authors of this Review are part. In the words of Jacques Viens, professor at the University of Montreal, "ICTs create a meta-effect; it transforms the vision of learning." (Viens, 1998). Soloway goes on to note: "The technology is the proximal cause; but quite frankly, the real issue is the teacher permitting and then encouraging students to work, to talk, to produce genuine artifacts, and to feel good about themselves and what they are doing in school" (p. 14).

The level of structure in teaching/learning activities is a major issue, and research results linking individual student characteristics with performance of online learning environments are not consistent in this matter. On the one hand, Linn and Davidson-Shivers (1996) pointed to those undergraduate students having higher field-dependency as those showing more positive attitudes when using less structured instruction in a computer-based hypertext environment (p. 326). On the other hand, the self-study conditions (independent learning) that provide interactive learning environments may be quite effective as demonstrated by Martens, Valcke and Portier (1997); see also the section below on higher education. As suggested by Hill, and Hannafin (1997), helping learners to construct a functional mental model of a particular system, and providing searching tips for wise selection, should increase their chances of success in finding desired information (p. 61). They concluded that "efforts to foster divergent thinking and multiple perspective building, as well as critical thinking and problem solving, are needed to assist learners in adapting to these environments" (p. 62).

The Project-Based Learning Support System (PBLSS) was designed and field-tested in an "attempt, through a collaborative design process with teachers and students, to develop tools and structures for doing projects that reduce the teacher's burden and that make student success more likely" (Laffey, Tupper, Musser, and Wedman, 1998). The TACT website is a virtual community of support for preservice, inservice, and teacher educators that offers a variety of resources and telelearning tools for inquiry into teaching and learning in technology-rich environments.

The National Council for Accreditation of Teacher Education (NCATE) in the US stresses (1997) the importance of "the ability for teachers to obtain and interpret information quickly and accurately" in a section on the Impact of Technology on Teaching. The NCATE Report goes on saying:

The introduction of computers and other technologies into schools is occurring at the same time that three decades of research in the cognitive sciences, which has deepened our understanding of how people learn, is prompting a reappraisal of teaching practices. We know from this research that knowledge is not passively received, but actively constructed by learners from a base of prior knowledge, attitudes, and values. Dependence on a single source of information, typically a textbook, must give way to using a variety of information sources. As new technologies become more readily available and less expensive, they will likely serve as a catalyst for ensuring that new approaches to teaching gain a firm foothold in schools. (p. 3)

Harrington (1996) has shown the potential of online activities to foster participation and democratic behavior in preservice teachers. Her findings, which suggest "that conferencing activities enable students of teaching to struggle with the dilemmas of teaching within a community of peers" (p. 16), corroborate those of Harasim (1997), and of Hiltz and Wellman (1997) pertaining to higher education as a whole (see the section below).

Cognitive science research results raise the level of what is now expected of teachers and of all other professional educators even much higher. For instance, Knapp (1997), emphasized:

> [I]f systemic reforms in mathematics and science are to be realized fully in classrooms, teachers must engage in a long-term process of learning that resembles the kind of constructivist processes that they and reformers hope will characterize students' classroom experiences. Individuals at other levels of the system who are in a position to support teachers' work directly or indirectly ? principals, curriculum

> coordinators, professional development organizers, superintendents, state agency officials, and even board members and parents - face a similar learning challenge. They too must grasp what mathematical ideas might underlie subtraction and long division or what integrated science might imply about disciplinary boundaries they have long held sacred (pp. 252-253).

For Lieberman and Grolnick (1996), educational reform networks are becoming increasingly important as alternative forms of teacher and school development. Collaborative learning is also a way to meet the higher expectations of a knowledge society. Some online teachers are developing learning programs and materials in partnership with educators and others (see Ahola-Sidaway and McKinnon, 1998). The Vision Statement of a group of educators presented to the SchoolNet Advisory Board, which put forward (1996) the notion of interconnected learning communities (http://www.tact.fse.ulaval.ca/fr/html/svision.html), pointed to the necessity of such collaborative work to enhance teaching and learning.

There is more to say about the contribution of online resources and tools to teaching in teacher education programs, and the section on higher education will provide more results in that domain.

With respect to **the governance of the integration of ICTs in education,** the current review points to the following trend:

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4.1.7 Trend 7: *Educators see online technology as a driving element of an educational reform.*

The work involved in developing powerful uses of ICTs in the classroom must be considered in the context of school reform (see Means, 1994). Evidence is building on the mutual dependencies between the use of online tools for learning and school reform or school improvement efforts: Powerful and sustainable uses of online tools tend to appear in the context of broader school improvement initiatives that offer direct support for technology and, vice versa, sustainable school reform initiatives tend to benefit from giving technology a serious place in the improvement process. This section illustrates these relations and points to sources in the research literature that document the circumstances and consequences of such interdependencies.

In his introduction of state-of-the-art practices for the *1998 ASCD Yearbook on Learning with Technology,* Chris Dede remarked: "The Yearbook focuses on exemplary projects with the potential to re-conceptualize schooling" (p. V). He went on stressing four types of improvements in educational outcomes of technology-based pedagogical strategies: learner motivation, advanced topics mastered, students acting as experts, and better outcomes on standardized tests (1997, pp. 210-211). Educators that subscribe to the Type II Approach mentioned earlier, that is, those seeing online technology as an enabler of new teaching, learning, and governance practices, may only have at this point scarce information with respect to the potential of its use for classroom and school improvement, but they are developing plans, policies, and reallocating resources devoted to the integration of ICTs into education. For instance, the Executive Summary of the Report of the President's Committee of Advisors on Science and Technology (1997) stresses:

> While a number of different approaches have been suggested for the improvement of K-12 education in the United States, one common element of many such plans has

> been the more extensive and more effective utilization of computer, networking, and other technologies in support of a broad program of systemic and curricular reform. (p. 26)

Piper, Power, and Stevens (1998) observed that the Vista School District Digital Intranet (Newfoundland) challenges the closed model of the school and manages geographic isolation in a new way.

European educators also see the potential of ICTs for transforming education systems. Plomp, Brummelhuis and Pelgrum (1997) suggest that the infusion of technology undergoes three phases: 1) the substitution phase, where the same practices occur using new technologies, 2) the transition phase, where new practice begin to appear and start questioning well-established practices, and 3) the transformation phase, where technology enables new practices and some old ones appear as obsolete (p. 463). They go on emphasizing that if educators persist in using ICTs as substitutes of current practices, they may not contribute to solving the educational problems now being encountered.

The successful implementation in the classroom of online technology beyond the basic level takes place in a supportive context. Kerr (1996b), the Editor of the Ninety-fifth Yearbook of the National Society for the Study of Education, entitled *Technology and the future of schooling,* conducted studies that led him to observe the following:

> [C]ontrary to the expectations of some pro-technology advocates, the process of adopting new devices and the approaches they make possible is neither rapid nor easy, nor does it automatically lead to the sort of revolutionary restructuring of teaching that proponents have predicted (.) teachers, appropriately supported and encouraged, can use technology in ways that allow classroom experience to be reorganized and that provide new ways for teachers to recast their own professional roles. While this approach [does] not lead to rapid change, it [does] show that technology can alter how classrooms look and feel, and that computers have social implications in schools that go beyond merely making instruction more effective or giving students access to better tools (pp.115-116).

According to Kerr (1996a), the opportunity for teachers to work together on new patterns of instruction is also linked to the need for specific guidance to be provided on how to accomplish those changes. Teachers' professional community as a factor in restructuring schools was examined by Seashore Louis, Marks, and Kruse (1996). They found that "comprehensive high schools that scored high on professional community exhibited a 'common language' of reform and consensus around a set of goals for themselves and their students" (p. 783). The overall evidence that they gathered made them point to "the need to emphasize the local development of schools as healthy, professionally sustaining environments in which teachers are encouraged to do their best job" (p. 787). The need for both guidance and community is evident specifically in relation to technology implementation, as illustrated in the following case.

After an intensive professional development program sponsored by the New Zealand Ministry of Education and the Christchurch College of Education, teachers voiced substantial pleas, according to Ham (1997), for greater democracy in decisions about technology. His survey pointed to "pressing concerns about participating in long-term technology planning and about ongoing support" (p. 67). "Our teachers wanted greater involvement in policy and decision making about technology and a sense of long-term planning rather than 'ad hocery' (p. 68)". The importance of top-down support and bottom-up change could not be overstated here. Active support is required, from peers, school administrators, or school districts mostly in the form of guidelines, policies, visions, site-based decision making, and communication channels

(Macmillan, Liu and Timmons, 1997).

For instance, constructed content may challenge the curriculum, and conventional measures of achievement, whereas 'canned' content on CD-ROM tends to be pre-organized in ways highly consistent with such curriculum and measures of achievements which are often designed, according to Dede (1997), to assess a narrow range of knowledge. Knapp (1997) assembled studies and analyses of large-scale systemic reform initiatives aimed at mathematics and science education, especially those undertaken by state governments and the National Science Foundation. He found a lack of alignment among key elements of the system, stressing that "either elements directly contradict one another (as when tests oriented towards discrete basic skills are retained while a curriculum emphasizes advanced skills) or simply ignore one another (as in textbook choices made without reference to teachers' preferences, beliefs, or knowledge base)" (p. 230).

Efforts devoted to align elements, especially those "dealing with what is taught, how it is taught, how learning is assessed, how teachers are prepared and supported, and how they are held to account for student performance" (p. 230), are likely to create issues and debate among professional educators, at local, regional, and provincial sites. For instance, White and Purdom (1996) viewed the confusion and debate on the use of computers and related technologies in schools as reflective of conflicting philosophical orientations to curriculum.

The infusion of online technology in elementary and secondary classrooms does not diminish the controversies and conflicts that pertain to school improvement efforts. On the contrary, it illuminates existing debates from new positions. It acts as a debate catalyst, as individuals bring to the debate their own perceptions of what technology can do or not, and of what school is about (see the section on critical issues, on the Canadian Teacher Federation website (http://www.ctf-fce.ca/e/what/restech/ART&PAP2.htm). Fullan (1993) pointed to considerable controversy that improvement efforts generate. Fullan does not focus on technology per se, and neither does Hatch (1998), in his analysis of the ATLAS Communities Project - a partnership between the Coalition of Essential Schools, Education Development Center, Harvard Project Zero, and the School Development Program in the U.S.. Hatch points to the differences in the theories of action held by different people and organizations, some of them including technology as part of reform, and others not, are deep and cannot be ignored. He observes:

> Even in a case where there was considerable agreement on goals and mission - when differences in approach were viewed as simply a matter of emphasis and not direct disagreement, where good relationships existed at the highest levels, and when significant funding was provided -different approaches to three of the basic dilemmas of schooling made it extremely difficult to make decisions and to carry out the collaborative work that school improvement required (p. 24).

The three dilemmas Hatch is referring to are the following: 1) how to establish wide support and foster innovation at the same time; 2) how to balance the needs and interest of students, teachers, and society in the curriculum; and 3) how to balance the need for autonomy with the benefits of support and direction. Recognizing that the different theories of action at play among partners with a long experience in school reform were making success difficult if not impossible to achieve, he recommends "exploring how theories of action grow out of different experiences and perspectives may provide one avenue for understanding and appreciating the rationale and logic behind a number of different approaches to educational reform (p. 27)".

Other trends, identified by Westbrook and Kerr (1996), related to reform and governance, are the following: 1) implementation of ICTs in principle brings about changes in the funding priorities and patterns, not only in terms of computer equipment and software, but also rewiring and reconfiguring classrooms, maintenance costs for equipment, and professional development and technical support; 2) the actual per-pupil funding for ICTs tends to be small (around 3%) and below estimates of what would be required to achieve the level of technology desired by some educators, policymakers and parents.

Before the Review Team points to the gaps in research on ICTs in education, one more point must be made. Educational administrators are seeing, as well as teachers, their practices challenged by online technology which enables more horizontal relationships between professionals working towards the same educational goals. Kerr (1996a) remarked that:

The challenge for administrators, many of whom have spent all their lives in systems that are thoroughly bureaucratic, is no less than that for teachers; the problematic features of bureaucratic systems are less amenable to individual solution (as are many of teachers' practices) and more often codified in various sorts of district regulation, administrative code, and state law (p. 25).

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4.2 Gaps in current knowledge about online use of technology in the K/12-13 classroom

The framework adopted for the analysis of online technology use for instructional purposes, and the emerging trends outlined above, indicate a number of gaps in our current knowledge of the impact (both existing and potential) of online technology on teaching and learning. In summary form, these gaps include the following:

4.2.1 Connectivity and access

Substantial access to online technologies, in terms of both resources and learner competence in making use of them, remains the exception in our classrooms. Given limited connectivity and access, research results reflecting practical uses of online resources and tools in the elementary and secondary school classrooms are scarce. More information is needed on what up-to-date resources are available (Schofield, Davidson, Stocks, and Futoran, 1998, p.371), the technology planning process of schools, boards, and faculties of education (ASCD, 1998; NCATE, 1997), and the ability of students to make effective use of online resources (Schacter, Gregory, Chung, and Dorr, 1998).

For example, research gaps would be reduced, and educational research in Canada enhanced, by investigating:

- The level of Canadian teachers' experience with computers, building on the findings of Rosen and Weil in the United States (1995);
- The level of student access to computers linked to a network (intranet and Internet) for subject specific tasks or project- and inquiry-based learning that integrate a number of subject matters, using school technology plans.

4.2.2 Professional development about online resources

Effective use of online resources for learning means pairing the resources with an instructional approach that is very different from the traditional one. More information is needed on the nature and extent of teacher's experience with information technologies (Rosen and Weil, 1995), how teachers view these resources (Kerr, 1996), how they understand their impact on society as a whole (NCATE, 1997), and how they alter their instructional practices in order to use them effectively (Haymore Sandholtz, Ringstaff, and Dwyer, 1997; Maring, Wiseman and Myers, 1997). More information is needed on online professional development activities (nature, process, and results) (see Moonen, B. and Voogt, J., 1998; Breuleux, Laferrière, and Bracewell, 1998).

For example, research gaps would be reduced, and educational research in Canada enhanced, by investigating:

- collaborating partners' theories of action, one that would build on Hatch's results (1998);
- educators' perceptions of the properties of online technology as ? "a tool for improving the ways we do things now, a set of devices and procedures that allow us to extend the efficiency and the effectiveness of schooling without altering underlying assumptions about the roles and relationships of the students, teachers, parents, and administrators involved (.) or a very different kind of tool ? one oriented toward the development of individual capacities in a social context and toward restructuring the work of schools", as Kerr puts it in concluding Chapter I of *Technology and the future of Schooling* (1996).

4.2.3 Stable versus dynamic content of curriculum

The content of what will be taught using online resources is becoming more diverse and shifting towards more construction and input by the learner. More information is required on whether this more dynamic content conflicts with traditional curriculum content and goals (Saye, 1997), and, where it does, on how to reconcile these conflicts (Hewitt and Scardamalia, 1998).

For example, research gaps would be reduced, and educational research in Canada enhanced, by investigating:

- the mind-sets that are behind the conflicting practices of educators (beliefs about content, method, organization, and evaluation of curriculum), building on White and Purdom's results (1996).
- progressive curricula directed toward higher order thinking skills, building on McGilly (1994), and Scardamalia and Bereiter (1996).

4.2.4 Performance indicators for evaluating the use and impact of online technologies

As the presence and use of information technologies becomes increasingly widespread, schools and universities will need to develop performance indicators to monitor the use and outcomes of the technologies, and to demonstrate accountability to funding sources and the public. These indicators are needed specifically to monitor the types of resources available, and access to them, professional development efforts, changes in teaching and learning practices, and changes in what is learned by students (Becker, Riel, Ravitz, and Anderson, in press; Wenglinsky, 1998; Windschitl, 1998; Bordia, 1997; Harrington and Quinn-Leering, 1996):

- beliefs about what constitutes success, for instance, building on Knapp' findings in math and science education (1997);
- advanced topic mastered with the use of online resources and tools, building on Dede's findings as editor of the 1998 *ASCD Yearbook on Learning with technology;*
- outcomes on standardized tests, building on Wenglinsky' findings (1998);
- many other research projects which would be of a sufficiently high (complex) and formal level to support conclusions being made by technology adopters when learning outcomes are considered, as pointed out by Jones and Paolucci (1998) in their review of over 800 research articles associated with technology in education dating back to 1992. As mentioned by Wenglinsky (1998), the Mandinach and Cline's study (in press) will stress the need for the use of technology over well-defined periods of time in order to conduct controlled experiments that will contribute to build the evidence on its contribution to learning and teaching.

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4.3 The university networked classroom

As this review now moves in the higher education sector, one has to keep in mind that the characteristics of the four dimensions of the teaching/learning exercise (teacher, learner, content, and context) are here quite different than those in the elementary/secondary sector. Moreover, one has to keep also in mind the fact that universities' libraries and labs were networked before the colleges and schools doesn't mean that classrooms where the teaching/learning exercise takes place are now properly connected. Therefore, by "university networked classrooms", the Review Team refers to those rare classrooms that are physically connected to a network (intranet/Internet), but also to those classes conducting online teaching/learning activities when located outside of the classroom.

Because university professors are already involved in research work, the likelihood of finding studies conducted by practitioners in their own classrooms was good. This Review includes a separate document presenting further evidence of the observations below, and rich descriptions contained in the following annexed document, entitled *Trends in higher education,* which may also be accessed in the online version through hyperlinks.

4.3.1 Trend 1: *The emergence of a new mixed mode of learning: face-to-face and on-line learning activities.*

Throughout the years, from one semester to the other, different learning environments have been coming into contact with each other and merging with university teaching practices. These practices have developed through the perpetuation of conventional instruction, which, more often than not, involves formal presentations based on a professor's knowledge, on distance education broadcasting techniques that bring together a mixed clientele located off campus, and on the emergence of an 'in and ex situ' educational presence on television that were generated by the development and use of new information and communication technologies (ICTs). Lectures, videos, multimedia and telecommunications support the various learning processes, sometimes in a hybrid manner, and sometimes in a more integrated manner.

An analysis of articles from scientific and professional journals on the two main learning modes, those associated with the conventional systems of knowledge transfer and face-to-face meetings and those involving on-line teaching, points to educational gains, mostly self-reported, using on-line learning in undergraduate and graduate education:

- Better classroom organization, better knowledge communication, easier access to the scientific information used to demonstrate and illustrate what is taught, and an improvement in teaching quality: Barker, Banerji, Richards and Check Meng Tan, 1995; Silverman, 1995; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Crook, 1997; Downing and Rath, 1997; Harasim, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Moon, 1997; Murphy, Drabier and Epps, 1997; National Council for Accreditation of Teacher Association, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- A more obvious and sustained engagement among participants and better exchanges between peers: Walther, 1995; Academic Systems, 1997; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Austin, 1997; Brown, 1997b; Downing and Rath, 1997; Harasim, 1997; Hiltz, 1997; Jaffee, 1997; Light, Colbourn and Light, 1997; Murphy, Drabier and Epps, 1997; Swigger, Brazile, Lopez and Livingston, 1997; Wells and Anderson, 1997; Deden, 1998.

- A teaching mode that favors the development of an interactive dynamic that stimulates the processes of knowledge acquisition and retention in a more thorough manner: Silverman, 1995; Academic Systems, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Crook, 1997; Downing and Rath, 1997; Harasim, 1997; Hiltz, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Murphy, Drabier and Epps, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- A more equal sharing of knowledge among participants: Silverman, 1995; Walther, 1995; Anderson, 1997; Barker and Check Meng Tan, 1997; Davis, Wright, Still and Thornton, 1997; Harasim, 1997; Hiltz, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Maltais and Rondeau, 1997; Moon, 1997; Murphy, Drabier and Epps, 1997; National Council for Accreditation of Teacher Association, 1997; Wilson and Whitelock, 1997.

- A monitoring process that is more continuous and individualized: Silverman, 1995; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Austin, 1997; Hiltz, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Maltais and Rondeau, 1997; Wilson and Whitelock, 1997.

- Better participant integration: Walther, 1995; Anderson, 1997; Austin, 1997; Brown, 1997b; Light, Colbourn and Light, 1997; Murphy, Drabier and Epps, 1997.

- Better knowledge retention, a better re-investment and the transfer of knowledge to other, more suitable, fields: Anderson, 1997; Brown, 1997b; Kapur and Stillman, 1997.

4.3.2 Trend 2: *Information access is more direct, interactive and flexible.*

Students have access to databases, on-line documents, CD-ROM towers and Internet sites. Several successful initiatives have already appeared in the scholarly literature. This proliferation of on-line documents has positive educational spin-offs. In fact, several studies demonstrate the veracity of the following premise: easier access to on-line information increased motivation of both teachers and learners and generation of a certain degree of satisfaction on both sides, resulting in better academic results:

- On-line information is associated with greater satisfaction and increased motivation to acquire knowledge: Barker, Banerji, Richards and Check Meng Tan, 1995; Silverman, 1995; Walther, 1995; Academic Systems, 1997; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Austin, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Crook, 1997; Downing and Rath, 1997; Hiltz, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- On-line information is associated with flexible learning: Alavi, Yoo and Vogel, 1997; Barker and Check Meng Tan, 1997; Collis, Vingerhoets and Moonen, 1997; Davis, Wright, Still and Thornton, 1997; Harasim, 1997; Murphy, Drabier and Epps, 1997; Northwestern University, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Swigger, Brazile, Lopez and Livingston, 1997; Hanss, 1998.

- On-line information is associated with greater organizational formats and multi-faceted learning tools: Coltar and Shimabukuro, 1995; Novick and Fickas, 1995; Silverman, 1995; Bonk, Appleman and Hay, 1996; Carey and Minstrell, 1996; Koltay, Trelease and Davis, 1996; Alavi, Yoo and Vogel, 1997; Austin, 1997; Brown, 1997b; Davies, 1997; Davis, Wright, Still and Thornton, 1997; Ellis, 1997; Harasim, 1997; Jaffee, 1997; Murphy, Drabier and Epps, 1997; Northwestern University, 1997; Shabo, Guzdial and Stasko, 1997; Sloane, 1997; Svanum, Chen and Bublitz, 1997; Swigger, Brazile, Lopez and Livingston, 1997; Varnhagen, Drake and Finley, 1997; Wythe, Rozum and Gore, 1997; Bachman and Panzarine, 1998; Burden and Davies, 1998; Hanss, 1998; Reed and Afjeh, 1998.

- A better grounding in the realities and professional practices of given fields: Silverman, 1995; Hayes and Lehmann, 1996; Parker, Walis, Halama, Brown, Cradduck, Graham, Wu, Wagenaar, Mammone, Greene and Holman, 1996; Austin, 1997; Davis, Wright, Still and Thornton, 1997; National Council for Accreditation of Teacher Association, 1997; Oakes, 1997; Yaverbaum and Liebowitz, 1998.

- On-line information is associated to performance improvement: Silverman, 1995; Academic Systems, 1997; Anderson, 1997; Brown, 1997b; Downing and Rath, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Wells and Anderson, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

4.3.3 Trend 3: *Social interaction recovers its importance in the learning process.*

On the one hand, work conducted at the Open University in the United Kingdom, TÉLUQ (a Quebec university specializing in distance education), Athabasca University (Canada) and other institutions of the same kind, in particular in Australia and Scandinavia, indicates the existence of online social interaction that can be sustained when distance education students use a computer hooked into the network. On the other hand, evaluations conducted on university campuses by Continuing Education units show similar results. In addition, the number of publications on Computer-Mediated Communication, written by professors most often linked with universities with distance education students, is increasing. However, the range lies between a conclusive and a mitigated success (Bordia, 1997). The social environment in which the learning takes place is not only discussed, but emphasized as being of crucial importance. The teacher and context influence the nature of the emerging interactions and social relations:

- There is a higher amount of computer-supported social interaction when teachers take into account the "cultural" characteristics of the participants and their commitment to participate: Silverman, 1995; Austin, 1997; Calvani, Sorzio and Varisco, 1997; Jaffee, 1997; Light, Colbourn and Light, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Murphy, Drabier and Epps, 1997; Oakes, 1997; Wilson and Whitelock, 1997.

- There is a higher amount of computer-supported social interaction when learning objectives and tasks are clear and straight-forward: Silverman, 1995; Austin, 1997; Calvani, Sorzio and Varisco, 1997; Issroff and Eisenstadt, 1997; Jaffee, 1997; Light, Colbourn and Light, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Murphy, Drabier and Epps, 1997; Oakes, 1997; Wilson and Whitelock, 1997.

- Computer-supported social interaction is beginning to be perceived as equivalent to face-to-face interaction; in some respects, electronic interaction is even seen as better: Silverman, 1995; Walther, 1995; Alavi, Yoo and Vogel, 1997; Austin, 1997; Brown, 1997b; Russell and Cohen, 1997; Swigger, Brazile, Lopez and Livingston, 1997.

- Computer-supported social interaction is linked to knowledge communication and sharing and to instructional monitoring: Silverman, 1995; Alavi, Yoo and Vogel, 1997; Davis, Wright, Still and Thornton, 1997; Light, Colbourn and Light, 1997; Wilson and Whitelock, 1997.

- Computer-supported social interaction is linked to original and innovative collaborative and co-operative efforts: Alavi, Yoo and Vogel, 1997; Austin, 1997; Brown, 1997b; Collis, Vingerhoets and Moonen, 1997; Davis, Wright, Still and Thornton, 1997; Ehrmann, 1997; Ellis, 1997; Fortenberry, 1997; Harasim, 1997; Murphy, Drabier and Epps, 1997; Murphy and Williams, 1997; Northwestern University, 1997; Russell and Cohen, 1997; Western Governors University, 1997; Hanss, 1998; Horgan, 1998, Lévy, 1998.

- Participants' deficiencies in technological skills were found to have only a small impact on their ability to interact with each other: Ross, 1996.

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4.3.4 Trend 4: *The learning community, supported by networked technologies, is a new collaborative learning arrangement being tested in a great number of ways.*

The learning community is involved in a joint process of creating and pooling resources with a view to sharing knowledge, skills and attitudes. Whatever the supports provided, the learning community is built around the goals it wants to target. It is modeled on learning objectives. From a social aspect point of view, the learning community falls within a specific cultural context in which participants negotiate values and give meaning and purpose to their actions and learning activities. This collaborative process includes co-operation, exchange, mutual aid, and negotiation. Computer-supported social interaction allows the growth, to varying degrees, of productive dialogue-based interaction between participants that favor the physical as well as the virtual development of this kind of socio-cultural group. However, since the learning community often develops without being consciously aware of the nature of the goals it set for itself, it turns out that, at the end of the line, it gets mitigated results.

- Computer-supported learning communities require different organizational and operational forms compared to traditional classes: Brown, 1997b; Calvani, Sorzio and Varisco, 1997; Collis, Vingerhoets and Moonen, 1997; Issroff and Eisenstadt, 1997; Harrington, 1998.

- Computer-supported learning communities require a virtual sense of belonging, and of a common identity: Silverman, 1995; Watabe, Hamaleinen, Whinston, 1995; Koble, 1996; Calvani, Sorzio and Varisco, 1997; Ellis, 1997; Davis, Wright, Still and Thornton, 1997; Issroff and Eisenstadt, 1997; Murphy, Drabier and Epps, 1997; Murphy and Williams, 1997; Northwestern University, 1997; Western Governors University, 1997; Hanss, 1998; Horgan, 1998.

- Computer-supported learning communities promote constructive and innovative forms of communication: Silverman, 1995; Watabe, Hamaleinen and Whinston, 1995; Koble, 1996; Austin, 1997; Brown, 1997b; Davis, Wright, Still and Thornton, 1997; Ehrmann, 1997; Harasim, 1997; Murphy, Drabier and Epps, 1997; Murphy and Williams, 1997; Northwestern University, 1997; Western Governors University, 1997; Hanss, 1998; Horgan, 1998.

- Computer-supported learning communities are redefining the teacher's role: Silverman, 1995; Austin, 1997; Ehrmann, 1997; Ellis, 1997; Harasim, 1997; Murphy, Drabier and Epps, 1997; Swigger, Brazile, Lopez and Livingston, 1997; Harrington, 1998, Coalition for Networked Information (CNI), 1998.

4.3.5 Trend 5: *Computer resources are used to enlarge the notion of performance as regards teaching and learning on university campuses.*

Data from the preceding trends contribute to the identification of this fifth trend. The emergence of a mixed learning mode; more direct, interactive and flexible access to online information; the renewed interest in social interaction; and the development of learning communities contribute to the expansion of student performance. The improvement in understanding and the development of more in-depth knowledge, a critical mind, the ability to analyze and synthesize, and individual and collective attitudes are linked to improved performance. More specific repercussions which may be associated with student performance are the following:

- Online teaching increases the amount of time spent teaching, and improves teaching quality: Barker, Banerji, Richards and Check Meng Tan, 1995; Silverman, 1995; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Collis, Vingerhoets and Moonen, 1997; Crook, 1997; Davis, Wright, Still and Thornton, 1997; Downing and Rath, 1997; Ellis, 1997; Harasim, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Moon, 1997; Murphy, Drabier and Epps, 1997; National Council for Accreditation of Teacher Association, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998; Harrington, 1998.

- Online learning activities stimulate communication between participants, favoring engagement and participation: Barker, Banerji, Richards and Check Meng Tan, 1995; Walther, 1995; Academic Systems, 1997; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Austin, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Crook, 1997; Davis, Wright, Still and Thornton, 1997; Downing and Rath, 1997; Ellis, 1997; Harasim, 1997; Hiltz, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Murphy, Drabier and Epps, 1997; Swigger, Brazile, Lopez and Livingston, 1997; Wells and Anderson, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- Online learning activities may be linked to more equal sharing of knowledge among participants: Walther, 1995; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Davis, Wright, Still and Thornton, 1997; Harasim, 1997; Hiltz, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Maltais and Rondeau, 1997; Moon, 1997; Murphy, Drabier and Epps, 1997; National Council for Accreditation of Teacher Association, 1997; Wilson and Whitelock, 1997.

- On-line materials have been linked to a higher degree of knowledge acquisition and retention: Silverman, 1995; Academic Systems, 1997; Anderson, 1997; Austin, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Crook, 1997; Downing and Rath, 1997; Hiltz, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- Marked performance development has been observed: Silverman, 1995; Academic Systems, 1997; Anderson, 1997; Brown, 1997b; Downing and Rath, 1997; Kapur and Stillman, 1997; McAteer, Tolmie, Duffy and Colbert, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- Online learning activities have been linked to the development of in-depth knowledge and a critical mind: Silverman, 1995; Academic Systems, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Brown, 1997b; Crook, 1997; Downing and Rath, 1997; Harasim, 1997; Ellis, 1997; Hiltz, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Light, Colbourn and Light, 1997; Murphy, Drabier and Epps, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998.

- The use of online resources and tolls has been linked to a reduction of the amount of time spent on academic management: Barker, Banerji, Richards and Check Meng Tan, 1995; Silverman, 1995; Alavi, Yoo and Vogel, 1997; Anderson, 1997; Barker and Check Meng Tan, 1997; Crook, 1997; Downing and Rath, 1997; Harasim, 1997; Jaffee, 1997; Kapur and Stillman, 1997; Moon, 1997; Murphy, Drabier and Epps, 1997; National Council for Accreditation of Teacher Association, 1997; Richards, Barker, Check Meng Tan, Hudson and Beachan, 1997; Deden, 1998; Gilliver, Randal and Pok, 1998; Harrington, 1998.

4.3.6 Trend 6: *The university as an institution is invited to adapt its activity to new higher education needs.*

The Monterey Conference (Higher Education and the NII: From Vision to Reality) mapped out

(September 1995) future activities in the field of higher education, along with the influential papers written by Norris and Dolence (1995) and Massy and Zemsky (1996). Academics are being pressured by the economic community, which calls for education and training that are better adapted to the demands of the work world. Problem-solving based more on present-day realities, group work, continuous education, interdisciplinary knowledge, multiple social interactions between students and professors, metacognitive abilities, active learning based on clients' learning needs, and the integration of ICTs into educational processes are unavoidably becoming academic priorities. University instruction must be more open and flexible, say many social leaders, and potential students. A multitude of players from all levels of the education community must be involved in making several key choices. These choices must be coordinated for the new teaching conditions to be acceptable, accessible and practical. This requires innovation, cooperation, co-ordination, and collaboration (see the Unesco World Conference on Higher Education, Oilo, 1998). Online resources and tools are becoming increasingly available for educational communities wanting to meet these challenges:

- ICTs provide an opportunity to establish coordinated and innovative educational partnerships between the various sectors, public and private, of society; these partnerships are established at the institutional and regional levels and can also appear at the extra-regional, national and continental levels: Eagan and Greenfield, 1995; Ehrmann, 1995; Koltay, Trelease and Davis, 1996; Collis, Vingerhoets, & Moonen, 1997; Davies, 1997; Davis, Wright, Still and Thornton, 1997; Ehrmann, 1997; Ellis, 1997; Fortenberry, 1997; Moon, 1997; Murphy and Williams, 1997; Northwestern University, 1997; Paquette, 1997; Western Governors University, 1997; CRÉPUQ, 1998; Hanss, 1998; Horgan, 1998.
- ICTs support the creation and use of new tools for institutions' performance measurement and evaluation; these enable us to determine technology's impacts on and contributions to higher education: Ehrmann, 1995; Brown, 1997b; Ehrmann, 1997; Harrington, 1998.

4.3.7 Trend 7: *The computer linked to other computers constitutes an important element in the modification of academic administrative procedures at both the micro and macro levels.*

ICTs are setting a whirlwind pace for change. These technologies are altering how things are done. Services and resources for university communities are being transformed in such a way as to offer a new range of more effective and more accessible administrative-management and study-support tools to their clientele. Virtual libraries and online administrative and organizational management are becoming integrated into this new institutional environment:

- ICTs are altering the function of university libraries and are intrinsically changing the role of librarians: Eagan and Greenfield, 1995; Koltay, Trelease and Davis, 1996; Reid, 1996; Davies, 1997; Hirshon, 1998.
- ICTs are changing the organizational structures of universities: new resources, new services and new practices are developing, and these innovations are more effective than previous methods: Jacobson, 1995; Harel and Partipilo, 1996; Koltay, Trelease and Davis, 1996; Lehman and Fernig, 1996; Brown and Malaney, 1997; Davies, 1997.

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4.4 Gaps in current knowledge about online use of technology in the post- secondary classroom

The framework adopted for the organization and analysis of online technology use for instructional purposes, and the emerging trends outlined above, point out a number of gaps in our current knowledge of the impact (both existing and potential) of online technology on teaching and learning. In summary form, these gaps include the following:

4.4.1 Connectivity and access

The number of classrooms equipped with one or a few computers linked to a network (Intranet and Internet) is much smaller in universities than in elementary schools. However, the number of students who own a computer linked to the Internet is rapidly growing, and university/college labs are better equipped than those of secondary schools. Reliable data are missing, and up-to-date and accurate surveys are for all practical purposes inexistent. 'Access' being ill-defined, is also a moving target, as more bandwidth becomes accessible and software applications more demanding. Should we include in 'access' those students whose professor gives demonstrations during a lecture to a large class by borrowing content from the Internet, or should we include those requested to give an opinion on their networked laptop in a similar-size classroom (see the IBM/Laval U project to equip all incoming Business Administration students with a laptop for use inside and outside the university classroom)? An extended definition of access would be inclusive of working learners, special needs learners, and high quality materials. We have trouble keeping track of the effective resources that are available to post-secondary students (online access time provided to learners, quantitative/qualitative data on web-extended courses, assignments requiring online activity, and else).

Are the identity and work opportunities of the learner changing as he or she adopts online tools for inquiry and research purposes? Longitudinal studies of such Canadians are missing.

4.4.2 Professional development interface with online tools

The effective use of online resources for learning is linked to an appropriate pedagogy or instructional strategy. University professors have traditionally refused training in pedagogy. The evidence of the studies using a mixed mode as reviewed above is that effective teaching with these technologies requires training. Are their views changing in the face of the upcoming competition as the student will have more choices to acquire his or her knowledge? Do they still believe that online teaching and learning will remain static?

The teacher-as-an-artist may engage in desk-top publishing of multimedia resources, meet in the studio room with undergraduate students (see the EDUCAUSE model), or deliver a lecture in synchronous or asynchronous ways. The teacher-as-a-scientist may teach a course with research colleagues, go online for discussions with students involved in other universities' programs, or supervise the creation of teaching materials closely associated with his or her research activity. Case studies of Canadian professors having engaged in such activities could be a vital force in the development of new teaching practices.

4.4.3 Stable versus dynamic content of curriculum

The framework outlined above strongly suggests that the content of what is taught within online classrooms is likely to move toward a mixture of content 'borrowed' from the web, content developed by the professor, and content constructed by the learner. How will the proportions evolve over time? How will this affect the teaching dimension of university professors? The research dimension? The Review Team found no institutional research on these aspects, only projected views.

4.4.4 Performance indicators for evaluating the use and impact of online technologies on teaching and learning

Performance indicators are important for post-secondary institutions facing new challenges as an online learning environment develops. Adult students enjoy a wide variety of choices with respect to available online programs and courses (flexible delivery, community of learners' sense of belonging, Web-enabled communities of practice). The circumstances under which they may engage effectively and in a satisfactory manner in such programs, courses and learning activities, are being designed although very little research is taken place on the subject.

At the post-secondary level, the curriculum is much less prescribed, but textbooks usually are, at least at the undergraduate level. Evaluation has been up until now, the province of each professor, but the Western Governors' University is now making a breakthrough by separating the performance evaluation from the teaching process itself. How will students respond to such a change could be the subject of a longitudinal study in the near future. Furthermore, there is a need to document the problem of students hoping that their online program underlying their undergraduate/graduate studies will be recognized at the local level.

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5. Synthesis and recommendations

5.1 Synthesis

Access to electronic and online social networks entails new activities into classrooms, schools, and universities as teachers uncover the possibilities of online resources and tools for learning purposes. Moreover, the technologies used presently in some classrooms are often parts of collaborative research projects, and may be partially used to meet the required exigencies of a particular study. There are experimental results demonstrating the value of effective use of information and communication technologies (ICTs) on learning outcomes, but large scale studies pointing to higher academic achievement under appropriate conditions are just getting underway. We are aware that results could greatly differ depending on the circumstances of use. The technology and the teacher knowledge and skill can indeed make a strong difference. But this combination of circumstances is often missing, a factor that research findings often fail to display (see Armstrong, 1998).

Two most different models of use were found to be of help for the organization of mixed results:

TCLC - : teacher/transmitter, content/canned, learners/limited access, context/limited support; **TCLC** + : teacher/facilitator, content/constructed, learners/high access, context/extensive support. The four basic constituents of each model seen as a whole rather than in isolation, appear to be the best approach. In fact, to put the focus on one constituent at the expense of the others, raises superficial questions, and leads to fruitless debates. In our opinion, the fundamental factors we ought to keep in mind constitute a viable model for making sense of all the activities related to the use of online resources and tools, and its impact. In using these models, it is important to note that when one of these four elements varies, it affects the others.

To connect schools and classrooms is a necessary first step for teachers and learners to take advantage of the available online resources and tools. To expect that academic results will improve in the short run is unrealistic. In other words, the investment in connectivity alone constitutes a high-risk though, in some exceptional cases, such an investment may pay off substantially (see Unesco's paper at the 1998 Worldwide Higher Education Conference http://www.education.unesco.org/educprog/wche/index.html). A moderate-risk investment aims at combining technology with content (see the first results of Education Ministers' math initiative in partnership with a private company, Western provinces, Canada, in Macnab and Fitzsimmons, 1998) and for more intensive learner's access, this means a relatively easy way to good quality content (interactivity, visualization, simulation; online or on a CD-ROM). For low-risk investments, the favored choice by most people, teacher professional development remains (before, during and after electronic connectivity) the way to go for educational renewal.

In the early phases of network connectivity, access issues are numerous and the learning is *about* technology, and the acquisition of computer literacy is the learning goal. As attention turns to learning *with* technology, a variety of teaching options are available. By far, better results are obtained when teachers know how to take advantage of the teaching and learning possibilities (synchronous and asynchronous) in a networked classroom.

In the last few years, Canadian universities have put online learning on their agenda. Already many important education projects are being featured. Nevertheless, the number of leaders in this new field has not reached the desired level. Presently, we can count on the Simon Fraser University, the University of British Columbia, the University of Toronto, including the Ontario Institute for Studies in Education, and a few Faculties of Education such as it exists at the McGill University and l'Université Laval. The research and teaching activities of Télé-Université in Québec and Athabasca University must be singled out here as frontrunners in the realm of distance learning. These educational leaders have already initiated numerous innovative projects which are coming to the fore.

However, these endeavors and innovations do not have the scope that is noted in the British and American universities and colleges. Therefore, the growth in the number of actors associated with new partners remains a factor of major importance. The potential impact in the higher educational field is explored in the OECD's document, entitled the Global Research Village (1998). Networks are giving rise to a richer and stronger research activity. Will teaching activities follow a similar path?

Keeping i the seven points related to the higher education sector and their combinations with the models of use described above, the research orientations are bound to vary enormously in terms of results and end products. That integration of online resources and tools is a continuing process: On the one hand, it is growing but still limited, and on the other hand, the development of a deep, directional and innovative vision, fully aware of the requirements is still in its infancy.

The TL*NCE research program contributes to fulfill this research agenda, emphasizing the research on new pedagogies (themes 4, 5 and 7 in particular). The Cueno's team of researchers (http://socserv2.mcmaster.ca/srnet/evnet.htm) and others are evaluating a number of innovative practices. SSHRC has also supported a number of other research projects (see SSHRC's document entitled Information on Education and Technology 1992-1997). The Office of Learning Technology (OLT) is also supporting a number of research projects. In Quebec, the FCAR's *Action concertée* geared on ICTs (http://strauss.fcar.qc.ca:80/), support researchers whose field of inquiry deals with 1) computer and multimedia literacy, design and production asking question such as the following ones: how do students proceed when allowed to use on-line tools and resources? what kind of guidance do they need in order to produce meaningful designs and to communicate effectively using hypermedia? (See Bordeleau's, Deaudelin's, and others' projects); 2) the changing relationship between the learner and his or her classroom learning environment (new roles and forms of interaction, including changing patterns of communication and collaboration). There are also other studies addressing more generic questions such as changing patterns of access and participation, the relationship of the learner to content, the perceived benefits as attitudinal or developmental over use, time, and space, etc. (see Ed Week's 1998 Report (http://www.edweek.org/sreports/tc98/). The impact of technology on learning generates much interest, and the Council of Ministers of Education (Canada) has just commissioned two papers on this very subject.

5.2 Recommendations

In view of the above findings, we recommend that policy and research initiatives should be guided by the following new approaches:

- a reflective approach to teaching (teachers-as-researchers). The use of online resources and tools by teachers should be informed by reflective practice that takes into account empirical evidence, rather than personal theories-in-use. The teaching profession must aim in this direction. The significance of this change is that it almost certainly entails a revised approach to teaching that views, for instance, the learner as an agent responsible for constructing his or her knowledge while making use of pedagogical strategies that support him or her in the acquisition of intellectual autonomy.

- the collaborative learning/research approach. Online technology is evolving rapidly. The traditional knowledge transfer model of research followed by dissemination, may not be a-flexible-or-fast-enough a process to respond to the emerging needs, as is well-exemplified in the following paragraph.

- a design experiment approach. Issues of 'design' are prevalent today and could be supported by more direct "design experiment" frameworks for vigorous discussions of the contexts, contents, and processes that ensure the attainment of proper conditions for online learning. For such conditions to be established, it is recommended that the following research procedures be adopted:

- the visioning of a wired classroom, institution, or educational system emphasizing content and pedagogy;
- the planning of an incremental process of change;
- the implementation of the above approaches with a high level of coordination among

stakeholders responsible for education;

- the initiation of a renewal process with respect to all of the four constituents that must be combined to form models of use with built-in professional development activities;
- the endowment of research settings (meaning primary and secondary schools as well as colleges and universities) willing and capable of initiating and conducting:
    - innovative reflective action with respect to the learners' access to online resources and tools, teaching practices, and contextual factors;
    - relevant surveys, case studies, and longitudinal studies;
    - -assessment and performance reviews.

Canada could be at the forefront of this emerging domain of study if educational research programs parallel the well-developed electronic infrastructure (CANET 2). In order for teaching and learning practices to take advantage of the electronic infrastructure being provided in Canada, educational research must be called to action.

As regards the content, a variety of research areas are identified. First, a distinction is recommended between, on the one hand, research on the limited use of selected and appropriately supported resources and tools, and on the other hand, the development of a deep, intentional, directional and innovative vision, fully aware of the requirements, activities, and factors related to university teaching.

Research topics related to the traditional and complementary (Type I) approach:

- The environmental and pedagogical designs likely to enrich the acquisition and assimilation of knowledge and ability;
- Behavior and acquisition of abilities in online environments complementary to the face-to-face teaching/learning process;
- Pedagogical steps and performances likely to stimulate a greater motivation, a thorough satisfaction, and a better social integration in the process of acquiring knowledge;
- Technical supports, pedagogical methods and education contents likely to acquire the potential and basic elements necessary to face contemporary challenges;
- Educational values and outcomes associated with the use of online facilities as an enrichment and support to face-to-face encounters;
- Levels of control and autonomy acquired by learners in the process of identifying, selecting, choosing and using online information;
- Educational processes favoring a better academic climate and assessment methods (formative and summative);

- Evaluation tools needed to assess the cost of installing and developing online technologies, and the nature and degrees of competence to be acquired and assimilated in such environments;
- Development of strategic partnerships between the private and public sectors, and intra-institutional collaborations and organizational innovations made necessary by the presence of online teaching and teaching processes.

Research topics related to the collaborative knowledge building (Type II) approach:

- The conscious awareness of the existing knowledge and abilities among the participants in an online teaching and learning environment;
- Pedagogical methods likely to improve and stimulate online conscious and intentional processes of acquisition, assimilation and transformation of knowledge, as well as new abilities and attitudes;
- Roles and functions of the teachers and learners in a shared online environment, in which negotiation is a valued process of acquiring knowledge, abilities and new attitudes;
- Degrees of autonomy and expertise acquired by the learners in the process of identifying, selecting, choosing and using online information;
- Socio-technical designs susceptible to widen the scope and use of online open and flexible ways of learning;
- Cultural and psychological environments likely to create a favorable climate in the sharing and negotiating between participants building up an online communication;
- Online social interactions as regards the processes of shared and negotiated constructions of knowledge, abilities and new attitudes;
- Cultural processes in the setting up of electronic learning and communities of practice;
- Networking of learning communities linked to professional communities of practice in online teaching and learning environments;
- Qualitative and quantitative evaluation of performances in online open and flexible environments;
- Evaluation tools to measure the costs of installing and developing online technologies, and the nature and degrees of acquiring competences in such environments;
- Strategic partnerships between the private and public sectors, intra-institutional collaborations and organizational innovations required by online teaching and learning needs.

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Conclusion

The classroom is a place where order prevails. The infusion of information and communication technologies (ICTs) creates a zone of uncertainty for both teachers and learners, engaging them in a process of risk and exploration for some time to come. Research on one or the other of the four basic elements of each 'extreme' model of use (**TCLC -** : teacher/transmitter, content/canned, learners/low access, context/limited support; **TCLC +** : teacher/facilitator, content/constructed, learners/high access, context/ extensive support) while neglecting the others, is bound to lead to partial and confusing results. The Review Team emphasizes that a focus on one element at the expense of the others tends to raise superficial questions and unproductive debates. The interdependence of the four fundamental elements that this review takes into account (and highly recommends for consideration in all further inquiry) should be progressively documented with respect to the impact of online technologies on teaching and learning in the classroom. More recent conceptual developments occurring in other fields such as the learning organization framework, and the new domain of knowledge management, seem to point in the same direction.

In conclusion, the Review Team expects that those countries that develop rich conceptions of teaching, learning, content, and context as they provide knowledge building opportunities and shared social experiences to learners in the elementary, secondary, or post-secondary classroom will simultaneously enhance their research capacity. The significance of such a choice may be felt as one's reads the quite evocative recent Report, entitled: *The Global Research Village: How Information and Communication Technologies Affect the Science System* (OECD, 1998).

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APPENDICE A

Methodological notes

According to the statement of work, it was decided to limit the search to the impact of networking technologies on education. That is, studies focusing on the impact of the Internet (wide area networks) on schools, teachers, and learning were the main theme of the search.

The databases available via the McGill Library system searched include: ERIC, MEDLINE, Social Studies Abstracts, ABI Inform, Current Contests, PsycInfo, Sociofile, Humanities Index and Dissertation Abstracts. Eric was searched because of its focus on education. Medline includes a wealth of articles on medical education and was chosen as well. Social Studies Abstracts and Sociofile were chosen because they may offer a sociological perspective to new information technologies and education. Psycinfo includes many articles examining the cognitive and psychological impact of new technologies on education. Humanities Index includes articles from an anthropological perspective. Naturally, Current Contents offers the most recent articles while Dissertation Abstracts offers graduate thesis and research on the subject.

The terminology chosen had to find all articles and yet exclude those articles deemed not useful. Although the search strategy and terms may have differed somewhat depending on the database searched, the strategy used was:

Term	Reason
1 internet.ti,ab,hw	Primary term used. Title and Heading Word delimited the search
2 internet.sh.	Next, Internet was limited to Subject headings only.
3 1 or 2	The two previous sets were then combined
4 (world wide web or www).ti,ab,hw.	The WWW was chosen as a term because abstracts on the technology may omit the word Internet, although it is unlikely.
5 (computer mediated communication or cmc).ti,ab,hw.	Many classroom projects are based on email, a term normally described by CMC
6 3 or 4 or 5	All sets were then combined
7 (teach or learn or school).ti,ab,hw.	The terms teach, learn and school (all truncated so as all variations with the root word would be retrieved) were searched
8 6 and 7	The entire set was then limited to include the terms. That is, the abstract had to have the terms rather than either one.
9 limit 8 to yr=1996-1998	Date limits were then included
10 not library or proceedings	Library and proceedings were then excluded

Another strategy was to expand the term Internet and then limit it to subject headings, title, etc. This approach yielded approximately the same number of citations. Computer networks yielded the same number of hits as Internet and WWW. Articles on computer networks not connected to wide area networks were excluded.

The most useful databases were ERIC, Current Contents and Medline. Other databases contained little information, ABI Inform, a business oriented database being a case in point.

Strategy used (ERIC is not included).

SOCIAL SCIENCE ABSTRACTS <1984 to June 1998>
1 internet.ti,ab,hw.
2 internet.sh.
3 1 or 2
4 (world wide web or www).ti,ab,hw.
5 (computer mediated communication or cmc).ti,ab,hw.
6 3 or 4 or 5
7 (teach or learn or school).ti,ab,hw.
8 6 and 7
9 limit 8 to yr=1996-1998

ABI/Inform <January to June 1998>
1 internet.ti,ab,hw,co.
2 (world wide web or www).ti,ab,h,co.
3 (computer mediated communication or cmc).ti,ab,hw.
4 1 or 2 or 3
5 (teach or learn or school).ti,ab,hw,co.
6 4 and 5
7 limit 8 to yr=1996-1998
8 7 not proceedings,ti,ab,hw,co.
9 8 not library,ti,ab,hw,co.

CURRENT CONTENTS/ALL EDITIONS <Wk 01 1996 to Wk 26 1996>
<Wk 27 1996 to Wk 52 1996>
<Wk 01 1997 to Wk 26 1997>
<Wk 27 1997 to Wk 52 1997>
<Wk 01 1998 to Wk 26 1998>
<Wk 27 1998 to Wk 32 1998>
1 internet.ab,ti,kw,kp.
2 (world wide web or www).ab,ti,kw,kp.
3 (computer mediated communication or cmc).ab,ti,kw,kp.
4 (teach or learn or school).ab,ti,kw,kp.
5 1 or 2 or 3
6 4 and 5

SOCIOFILE / MEDLINE / PSYCHINFO / HUMANITIES ABSTRACTS
1 internet.ti,ab,hw.
2 (world wide web or www).ti,ab,hw.
3 (computer mediated communication or cmc).ti,ab,hw.

4 1 or 2 or 3
5 (teach or learn).ti,ab,hw.
6 4 and 5
7 limit 6 to yr=1996-1998

DISSERTATION ABSTRACTS
4 su:internet or su:(world wide web or www) and yr:1996-1998 633
7 ((teach+ or teacher or teaching)) 71072
8 (learn+ or learning) or 7 109959
9) 148

With respect to the francophone literature, the FRANCIS data base was reviewed, plus PsycLit as well as the Répertoire canadien sur l'éducation, using the following descriptors:
Internet
WWW
Technologies de l,information et des communications
Nouvelles technologies de l information et des communications
Télé-enseignement
Télé-apprentissage
Enseignement à distance
Enseignement supérieur
Impact, conséquences

With respect to higher education, ProQuest Direct (ABI/INFORM: Global) was surveyed for academic materials, and Amazon for book titles (multiple references to the same books pertaining to primary and secondary schools were also identified).

The number of retrieved citations was exceptionally large and had to be evaluated by hand. Articles not meeting strictly the above criteria were excluded (popular articles, articles not about schools or universities, etc.). The selection of research documents according to the criteria of a) validity, b) relevance, c) credibility of the source, d) descriptive vs. normative materials, e) emerging research, f) funding (grant agencies, business partners). Concrete experiments (category one) of significance carried out in a school or university classroom or in a group of classrooms, sometimes in collaboration with other organizations, were considered as the primary materials (category 1). Systematic actions conducted by educational leaders and their evaluations, chosen as significant, are other important materials (category 2). All materials reviewed are the result of a methodological approach defined under a pre-established overall plan and that regardless of the size of the experiments presently under consideration. Evaluations must have been documented properly.

Selection criteria of materials. Over one hundred documentary references are included in the bibliography on higher education. Ninety-sixth documents are dealing with various pedagogical experiments and/or innovations which took place between 1994 and 1998, in a context of university activities. The bibliography herewith presented outlines a variety of online teaching and learning approaches. It includes all kinds of methods and means such as: Internet, web sites, teleconferences, videoconferences and telepresence, virtual classes, educative platforms, data bases, online hypermedia and multimedia links, discussion forums on real or deferred time and electronic messages. All references to prospective articles dealing with theoretical and/or methodological analysis system, were carefully eliminated.

Marcos Silva and Tina Newman, graduate students in the Cognitive Laboratory at McGill University, and M'hammed Abdous at Laval University conducted the search. Mr. Silva possesses searching skills from his training as an academic librarian and Ms Newman is familiar with the research terminology used by Profs. Bracewell and Breuleux. Mr. Abdous has been working for three years with Dr. Laferrière as a member of the TACT (Technology for Advanced Collaborative Teaching) Team. Mr. Benoit has a Ph. D. in History and he is working with Dr. Laferrière as a new member of the TACT Team. He wrote the section presenting rich descriptions of experiments in Higher Education.

Research evidence leading to changes in school and university practice was gathered and analyzed by research assistants M'hammed Abdous, Jean Benoit (higher education) and Tina Newman (primary and secondary education) under the supervision of the senior researchers. Parameters identified in the Statement of Work guided the analysis of the materials. Special attention was given to socio-technical designs centered on students learning, educational leadership, and teacher professional development. Drs. Bracewell, Breuleux, and Laferrière undertook the final analysis of the literature applying rigorous conditions for the interpretation of what is known with respect to the question of the pedagogical uses of the Internet and intranets such as CSILE, and the identification of the gaps.

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